Industrial QUALITY CONTROL

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through
Scientific Methods

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From the President's Desk

Thanks to the Sections and Divisions

As you know, the amendment to increase the annual dues by $2.00 per year was defeated. Your Officers and Board of Directors had approved and recommended this modest increase to keep up with the ever-increasing costs of Society operation.

The present dues structure has been in effect since June 1950 despite the fact that the past seven years have seen some sensational rises in costs of doing business. The Society has held the line on increases, has cut every corner possible, has consolidated the offices in Milwaukee and closed the New York office, has placed the membership records on IBM cards for more efficient handling and instituted other time-saving and money-saving procedures. The growth of the Society has forced us to discontinue complete reliance on volunteer help and has dictated the addition of several people to our payroll. Also, the wages paid to employees have increased, just as yours have, during this period. The costs of supply items, printing, and every other conceivable item has also gone up. In short, we have been experiencing inflation.

At the recent election, only 3,233 members cast their votes out of a possible 10,479. The ASQC Constitution requires, for the adoption of any constitutional amendment, that 75 percent of the votes cast be in favor of the change. The members cast 2,357 votes in favor of the dues increase, but we needed 2,425. This means that the vote for the dues increase lost by only 68 votes. In addition, 83 Sections voted in favor, while only 6 voted against the amendment.

The funds which were needed for the current operation of the Society were not forthcoming because of the failure of the amendment to pass. At the request of the Board of Directors, I personally asked the Sections and Divisions to support the Society financially to the extent that they were able to do so. The response has been most gratifying. I, therefore, wish to express my thanks and that of the Executive and Operating Committees and the Board of Directors to those Sections and Divisions who have responded promptly and generously. I know that in many cases this was done despite local hardships. Below are listed those Sections and Divisions who have notified me of their intention to assist us in this emergency.

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Our hats are off to you for your support, and you can be assured that we will do everything in our power to provide you with the improved and increased services that you deserve.

Sincerely,

Leon Bass

Trends for Quality Control*

DR. L. R. HAFSTAD

General Motors Corporation, Detroit, Mich.

Mr. Bogin, Mr. Critchfield, distinguished guests, ladies and gentlemen . . .

After hearing Mr. Critchfield's introduction it ought to be clear to you that, with my work record, any sharp personnel man would spot me as a job hopper. That being the case, I wouldn't presume to talk to you as an expert on anything, let alone quality control. It is prudent, however, to make a virtue out of necessity. One thing that job hopping does is give you a real perspective—and thus perspective is something I can claim.

So I will try to give you some impression of what the quality control field looks like to me now—with such perspective as I have gained—and try to indicate some directions in which I think it probably will move and what fun it will be to watch it grow.

My own contacts with quality control go all the way back to my telephone company days when I was exposed to some of the early work of Shewhart. That was at least 25 or 30 years ago. The game has come a long way since that time. I am amazed to find such a large attendance here because in my day we talked about quality control in small graduate student groups of half a dozen or a dozen. Now it has become a really major profession.

SQC, Engineering, and Common Sense

This is very gratifying because as one who has done a bit of missionary work in this field, I am delighted to see that so many have found the true gospel. Quality control has become a specialized profession, but somewhat surprisingly, I think, engineering has been slow to pick it up. One can puzzle a little about this because our friends in the biological and agricultural fields got acquainted early with statistical methods and got used to the idea of distributions, the limits of distributions and so on. But, by and large, engineers were slow to pick it up.

I think we have had an uphill job selling mathematical statistics and quality control to engineering management because engineers flattered themselves that they could avoid variability. They insisted they could make things so uniform that they didn't have to worry about distributions. This had the additional great advantage that it saved them from the need for learning about the complicated mathematics that you get into when you deal with distributions.

Actually, as we all know, you can't escape variability. You can narrow up the distribution, but it's still there to tantalize you, if you wish to push it far enough. We have only recently pushed far enough in the engineering profession to start worrying about variability and statistical distribution.

Now, by and large, mathematical statistics in this field, I like to say, is only a quantitative expression of common sense. As such, it should be easily salable. Most of us have puzzled about the fact that common sense is so rare. I'm sure we've all discussed that in small groups. I've speculated a little bit about this, too. I believe as statisticians we can really understand it. I would put it this way: That good sense in itself, we all agree, is a pretty rare trait. But if you then look for good sense, which is common to a relatively large sample of a representative population, you find you are dealing with a product of probabilities which are all against you, and it gets to be a rare trait, indeed. This is my explanation of why common sense is so rare.

As individuals we should be able to sell our ideas of using mathematical statistics to our management, but we have a lot of trouble doing it. I think one reason is that to a large extent quality control or mathematical statistics has become a tool or a technique. Many people who use it are inclined to consider it as a skill or a ritual. This isn't quite enough. We have to do better than that. There is danger in too much reliance on ritual. If we use our technical jargon on management, we merely make them suspicious.

I'd like to tell one of my favorite stories here about what happens when you get too much involved in the mechanism. I don't know whether many of you have heard the story of the Irish balance, one of my favorite stories. It goes something like this.

The Irish farmers used to have the problem of weighing pigs in the old days. One of the ways of doing this was to hunt around and find a nice straight plank and then hunt around some more to find a stone with a sharp, smooth edge to it. Then you'd balance the plank on the stone, put the pig on one end and start putting rocks on the other. If you did your job properly and carried out the technique well, you'd start out with a big rock, then a smaller rock and pretty soon pebbles—and then tiny pebbles. Soon you'd have the pig exactly balanced with the rocks. Then all you had to do was estimate the weight of the rocks and, necessarily, this was exactly the same as the weight of the pig. And this solved the problem.

Now, to a large extent I think this sort of thing is done in some of our mathematical statistics approaches. We worry too much about the technique and the ritual and not enough about the initial basic assumptions. This leads to suspicion and mistrust. So I would like to urge that, as people who are operating in this field, we learn to carry out our ritual in private and learn to translate both the assumptions, the arguments, and the conclusions into plain English so ordinary people with

*Presented at the Eleventh Annual ASQC Convention, May 22, 1957, Detroit, Mich.

common sense can understand what we are talking about.

Statistics in the Engineering Field

It is pretty clear that much of the impetus for quality control in recent days has been given by the complexity of our modern technical devices, particularly in the military. We have learned a lot about quality control, reliability, and performance. I think it is important that we distinguish carefully between performance and reliability and realize that performance is something that can be measured but reliability is something that must be predicted.

This gets us into the probability field. We have learned in recent years that it is not enough to keep improving our components and to depend on really good components to give high performance for a complex assembly of devices. There are interactions and these have to be taken into account. We can do much even now in improving our components. Certainly, this has to be done. But I think here is a field for real research in our business. We must determine how much gain we can make by components and how much we have to make to get the performance and reliability in the assembled device by design and construction improvements.

Somewhere recently I read a quote that quality must be designed and built into a device—it cannot be tested into the device. This cannot be too much emphasized. There is a tendency in some quarters to feel that if you want better performance you narrow up your tolerance limits and that somehow this improves the performance. It doesn't necessarily follow.

There are other areas where I think much more research can be done and needs to be done. The business of quality control charts and three sigma limits—all of this which used to be a research subject—has now become standard practice in our factories. This part seems to be pretty well under control. But the question of what we do when we go out of tolerance is not fully understood, because once you start getting points out of tolerence you have many choices before you, and it isn't clear how to optimize. If you take your observations too close together, you are doing a lot of unnecessary work. If you have your observations spaced too much, you may run a lot of defective material before you start the correction.

Here is one place where I think this business of operations research must be brought back into our business of quality control—to figure out an optimum sampling system, or an efficient sampling system, so you get the most information with the least possible expenditure of effort and dollars. We cannot separate out quality control into a special little ritual in which you can become expert and not get the ramifications of it into other fields.

I think it is our job to move on into systems analysis and here people trained in statistics have a real advantage over engineers not so trained, becaue you are used to dealing with many variables at the same time. By and large, an engineer is used to controlling his devices and his processes in such a way that he changes only one variable at a time. This is comforting. But statisticians are used to dealing with materials in which you have many variables and when you start dealing with complex systems, this is what you are up against. Here again, I think, the mathematical statistician has much to contribute.

Now as to the scale of the problem we face, most of you are familiar with this. For some who are hearing these figures for the first time it might be of interest to know that according to Air Force figures it costs about two dollars for maintenance for every dollar of expenditures for equipment. This becomes a very big investment, indeed, and indicates why it is that performance and reliability are really worth a lot of dollars. We can justifiably spend a lot of money to get it.

Another way of emphasizing this is to give you a figure of this kind: In order to add a 6-kw electrical load to an airplane—let's say for heating filaments of vacuum tubes—the plane weight is increased by 1540 pounds, in this example, and the cost of the plane by 60,000 dollars. It is evident that it should be a fairly good investment to spend money in developing components—reliable, small energy consuming components—and save some of the 60,000 dollars. Also, it should be clear that with such a premium of space and weight saving, an excessive safety factor becomes a great luxury, indeed.

One may ask why it is so difficult to get sufficient attention paid to reliability and the development of components? One can cite the fact that as complicated mechanisms, such as airplanes or guided missiles, are made, only a fraction of them are good. The other fraction is bad.

Reliability studies and a reliability team could greatly increase the number of good units that are produced. But it is difficult to get money to pay for reliability teams. Why is this? It seems to me that eliminating failures should be just as valuable as increasing production. We have all learned in mathematics that two negatives make a positive, so that the reliability team is producing just as much as the assemblers.

But this is not in accord with bookkeeping practice. I think it is worth speculating on the fact that reliability people are overhead and non-productive people even though I'm sure they can eliminate a lot of failures. Here is some very simple mathematics which we haven't learned to take advantage of up to the present time.

In the reliability field, particularly in fatigue testing which is of much interest to the automotive industry, I think recent developments along the lines of the Weibull approach have been very, very effective. It has the great advantage of reducing data to straight line plots and this is much more simple to use and interpret. It seems to me that we could go much further in that direction even in components for electronic and other apparatus than we have done in the past.

However, this is not the whole story because in the kind of things we are now working with—let's say guided missiles—it isn't too helpful to know the number of hours up to which ten percent of the components will fail. In a guided missile you don't want any of the components to fail. You can't afford it. And I would add (now learning about the automobile business) the way automobiles are built and used, I don't want automobile parts to be failing ten percent of the time, either. What I'm interested in is the length of time up to the first failure or how much time can you depend on before you get the first failure? How steep can we make the onset of failures? And can we devise a safety factor such as the mechanical engineers used to use in their designs which will keep us well below the onset of failure? Or, if we can't do that, at least we ought to have some quantitative measure of the separation between the operating point and the onset of failure.

This brings us back to the engineering side and indicates why we have to have close interaction between the statistical quality control people and the engineers. It seems to me that as engineers we have to devise more uniform materials in the ball bearing race, for example. We ought to design ball bearings so

that they all fail at the same time like the one horse shay and don't start dribbling in with failures at about ten percent or one percent of the life of the longest lived ball bearing. This is a problem for the metallurgists and the engineers, but it's a problem for you people to develop tests and evaluations which will give us a measure of how close we are coming to that particular goal.

Quantitative Common Sense in Fields Outside Engineering

I've talked mainly about statistics in the engineering field. I would like to turn now to a little broader approach. It seems to me there is plenty of room for quantitative common sense—and this is what we are custodians of, remember?—in lots of fields outside of engineering. We must get into systems engineering involving perhaps the operator as well as the mechanical device. Who, for example, is doing quality control on automobile drivers? I think the statistician and the engineer have to get more heavily into the field of economics. Here I'd like to quote a short paragraph from Mr. Cordiner of the General Electric Company, which I think is very pertinent. He says:

"Management (that's what he's talking about and I think the same thing applies to us as industrial engineers) must go beyond the traditional assignment of making material things. And beyond this traditional assignment lies a whole spectrum of political and social responsibilities that are urgently clamoring for attention. These responsibilities must be managed with the same energy and effectiveness that the manager now accords to his material work. If he does not (and here I'm quoting Cordiner), I am afraid the professional manager will become as obsolete as the tycoon, and the work of management will be taken over by the state with political officials doing the planning and policy guidance while domesticated bureaucrats, the professional ex-managers, are assigned such administrative details as producing and selling goods. If these seem to be unwarranted fears, simply look at what has happened around the world in the past 40 years. The totalitarian states and the so-called mixed economies, which characterize most of the globe today, owe their existence in part to businessmen who failed to measure up to the full responsibilities of a free society and a free market."

I think this is a very serious and profound statement and I think it indicates and suggests that industrial engineers have to move on into the field of economics as well as into the straight manufacture of goods and materials. As management moves into this field, engineers with a background in statistics and statisticians with a background in engineering have very great contributions to make.

My discussion now leads to the subject of operations research, which I have been watching for some years. I think we are on what I like to call the second bounce. As with so many new things, there is a period of skepticism, followed by a period of enormous enthusiasm and an expectation of magical results. We've been through that stage with operations research. Then you go through a period of disillusionment and only after that do you come to what I call the second bounce, and you start developing something which is solid and serious. I think that we are approaching that stage in operations research at the present time.

The Need for T-Men

As you know, in this field it has proved very useful to have what are usually called task forces attack a problem. You bring in a number of specialists, usually with varied backgrounds, and put them together in a team which tackles a problem as a full-time assignment. Some of these people must have good mathematical backgrounds, but it puts a premium on what has come to be called the T-shaped man. I don't know if you've heard of that expression before, but I think it is a very apt one.

In such task force assignments, it is extremely helpful, almost necessary, to have men who are really expert in some field or other. It doesn't matter too much what the field is, so long as he has depth in some one field. This gives him an appreciation of what is known and what can be known. It gives him a tolerance of other expert opinion. But he mustn't be tall and narrow—that is, know only the specialty. Otherwise he is likely to be bigoted and useless. You have to have enough breadth in this individual so that he can understand what the other experts are talking about. He must have the mental agility to follow their arguments. And this is why we talk of the T-shaped man because you can't often have a man who is both broad and tall. This is contrary to nature, but you can have one who is deep in his specialty and tolerant of other people's opinions.

The group here, I think, includes very many people of just that kind. This is one of the reasons why I feel there is so much need for this kind of a group and this kind of thinking.

Some Problems to Consider

I would leave you with a few problems to puzzle about in your spare time. I would urge you to continue the remarkable progress you have made in your specialty, and to broaden out and take a look at some other fields, particularly systems analysis, operations research and economics.

I would ask you to ask yourself what are the economic, social and political implications in referring to the gain and productivity that our technological society produces as "labor productivity." As mathematicians we are used to looking hard at our definitions. Economists use the word "labor productivity" to cover something that involves several terms rather than a single one. I think this has serious implications for the supply of scientists and engineers and, therefore, for our industrial future.

Again, I would mention the thing which I touched upon before—I ask you what are the economic implications of calling the work of quality control people and reliability people non-productive labor? This applies also to engineers, as you know.

I would like to ask then how does it happen that an engineer who produces a machine that increases the efficiency of labor, and enables it to accomplish more with the same amount of human effort, is doing non-productive work? I can't understand that. These are bookkeeper definitions and the economist works with these definitions in arriving at his conclusions.

I think I have indicated to you why it is that I feel this group has many opportunities and many responsibilities that go well beyond the immediate field of quality control in which you are now so expert.

I would like to urge upon you that the adventure and excitement, the creative satisfaction, and the fun of research consists mainly in moving into new and unexplored territory.

I hope that you people in QC don't become so enamored with your short-range projects that you miss the fun of exploring new fields.

I would like to end with an epitaph which is supposed to have come from a New England tombstone, which goes like this:

Here lie the bones of Spinster
Jones,
For her, life held no terrors.
Born a virgin, died a virgin;
No hits, no runs, no errors.

Statistical Quality Control Methods at Rome Cable Corporation*

C. KENNETH HAMLIN

Rome Cable Corporation, Rome, N. Y.

This article will attempt to show how we are using statistical quality control procedures and techniques at Rome Cable Corporation. Although the discussion will be devoted mainly to examples of quality control at work in our plant, it may be of interest to point out first why we are so completely sold on quality control methods.

Why We Believe in SQC

Like other manufacturers of electrical wires and cables, our quality problem, or more properly, our quality "control" problem is a difficult one. Our products are made to rigid specifications. These include those established by the Underwriters' Laboratories, Inc., the American Society for Testing Materials, the Insulated Power Cable Engineers Association, American Association of Railroads, and many others. Many customers also have their own specifications. However, in practically all cases, these specifications state the requirements for the finished product. It is our responsibility to produce material that in finished form will meet many requirements including dimensions, physical properties, electrical, mechanical, and aging characteristics, to name just a few.

Since most of these specifications are written for the finished product, and sampling for compliance is performed on the finished product, we need some sort of yardstick for measuring product quality level throughout the entire manufacturing process.

Although we do manufacture large quantities of the same type of cable, our individual processes can be thought of as "job shop" in a great many instances. The nature of our product dictates that quality must be high, yet it must be sold in a highly competitive field.

All of these factors combine to make the responsibilities for *producing* quality product, and for maintaining proper and adequate checks, very great indeed. Quite naturally then, we are constantly on the alert for new and better methods for improved product quality, lower costs, and more economical inspection without sacrificing performance or reliability of our product.

Our Introduction to Statistical Quality Control

Several years ago we were awarded a large government contract for a special type of communications cable. To fulfill this obligation, Rome Cable Corporation increased its production capacity by the addition of a new building, equipped solely for the production of this cable. This production unit was completely staffed and equipped as an operating unit in itself. As such, we were able to institute, try out, and evaluate many new procedures and methods. It was during this program that we learned how to use statistical quality control methods to advantage.

Before this initial program was completed, we had compiled and published a complete "Manual of Quality Control and Inspection Procedures" for this department. Practically all of the procedures contained in this manual, whether for process control, in-process inspection, receiving inspection, acceptance inspection, etc., were based on statistical quality control concepts.

Perhaps most significant, aside from the benefits our company realized as a result of this program, was that the Government agency, after a long and thorough look at our methods and procedures, decided that it could not better what we were doing. In fact, it eliminated its inspection as such, and confined its activities to the surveillance of our methods. This type of quality assurance program has been designated by the U.S. Signal Corps as RIQAP (Reduced Inspection Quality Assurance Plan). We are proud that we were the first Signal Corps contractor to be given this recognition. Although many of the policies that are basic in this program were established prior to RIQAP, the program as we know it today is the end result of a cooperative study of quality problems which was undertaken by Signal Corps and Rome Cable quality control personnel.

Although this achievement was not easy, it certainly provided the stimulus and confidence needed to expand into the entire plant. More important perhaps, the value of these methods was so clearly demonstrated that other operating departments began asking for "quality control" coverage in their departments.

Setting-Up for Quality Control—Our Philosophy and Objectives

Our philosophy has been to introduce and take advantage of statistical quality control methods whereever possible but, at the same time, move slowly and with extreme caution. This has been possible because we have had for some time a strong, well developed inspection organization. Our aim has been to supplement this department in the plant without jeopardizing, or in any way detracting from, the prestige this department has built up. Actually we have been able to help the Inspection Department reorganize many of its procedures for greater effectiveness and efficiency.

Introducing Statistical Quality Control Methods—In-Process Control and Final Inspection

Unfortunately, the actual application of statistical quality control techniques in the manufacture of electrical wires and cables has been slow compared with the published progress made in other fields. To those of us involved, the reasons are

*Presented at the Ninth New England Quality Control Conference, Hartford, Conn., Nov. 4, 1955.

easy to understand and seem valid. Like others, we at Rome Cable are familiar with statements such as "An eighth grade student can operate control charts" or "Statistical procedures are applicable to any process," etc. However, when we try to apply the so-called "cut and dried" methods, they just don't fit. A multitude of obstacles seem to pop up immediately.

Of course, we all make an honest effort to overcome these obstacles and finally do reconcile the problem —somehow.

One of the biggest obstacles to overcome, in our experience, is the man-power and paper-work requirements that usually go along with a new procedure. Naturally, as statistical quality control people we want all the information on a process we can possibly get. Many times this leads to detailed, and sometimes, rather complicated forms.

Two extreme solutions immediately suggest themselves: (1) Modify the procedure and get along with something less than satisfactory, or (2) Use your authority and make it work. Our experience at Rome Cable over the past several years has taught us that neither of these is the real solution.

Genuine quality control must be willingly accepted by the operator. Once this is accomplished, it is the quality control engineer's responsibility to provide him with all the possible tools (statistical quality control tools included) to do the job.

We believe that it is part of our job to cooperate with the operator in maintaining his equipment in proper condition. Over and above this, we try to see to it that he is provided with, or has, the use of all the necessary mechanical tools, instruments, gages, etc., that are essential on his job.

Since the operators are not trained in our methods, they naturally do not know what benefits are possible through the use of statistical quality control methods. Our approach has been to try to arouse their interest and through this means, get them to work with us.

Much is written and spoken about inspector-operator relationship on the job. Although we are often quite likely to consider this subject "just good reading material," our experience has taught us that there is no substitute for the understanding and cooperation of the man on the job. For this reason, we try to work at this level first. Perhaps the Quality Control Department doesn't get all the credit or publicity due in some cases, but the *real* gains made are worth this sacrifice in the long run. Of course, we report to management, but we try to work with the operator and his immediate supervisor first. We find that once we have gained the confidence of the operators, and are "on the inside," so to speak, the kind and amount of information passed along is surprising. We try to use and pass this information along in a way that will improve conditions without affecting our relationship with the men.

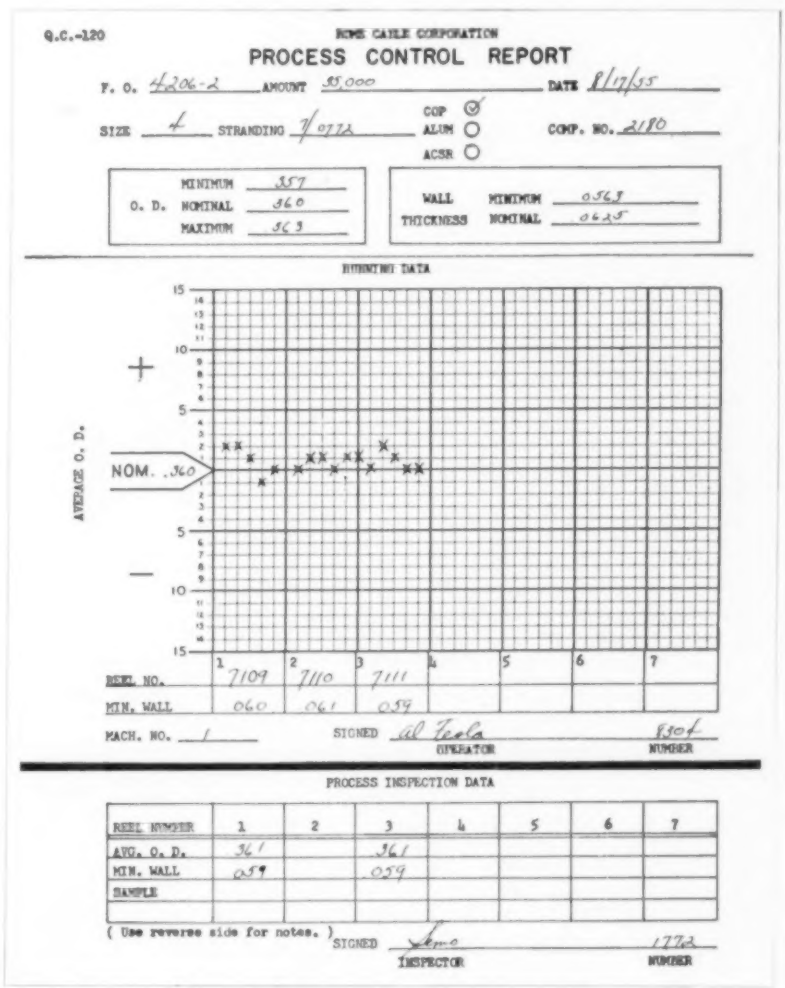
Admittedly, this method of approach is a slow, almost painful one at times, especially for those of our group who are already completely sold and anxious to "go." However, in the long run, procedures installed under these conditions seem to function efficiently with little or no push, whereas procedures installed without the complete cooperation of the production unit often require constant attention.

So much for our ideas regarding the introduction of quality control plans to operators. Do we have similar problems with our Final Inspection Department?

Here we have different problems for vastly different reasons. Final inspection people are primarily concerned with defect **detection** and not defect **prevention**. They are interested in the best possible methods for preventing shipment of defective material. Thus problems in this area center around sampling plans and procedures and the correlating of process data and inspection results with sampling.

Here again, one of our main problems is paper-work and man-power. In several instances, we have completely reviewed our reporting and record keeping methods and have been able to streamline and, at the same time, improve these methods through the application of statistical quality control methods. Some examples will follow.

No program would be complete, of course, without emphasis on improved product quality and reduction


Q.C.-120

ROME CABLE CORPORATION

PROCESS CONTROL REPORT

P. O. 4206-2 AMOUNT 35,000 DATE 8/17/55

SIZE 4 STRANDING 7/0772 COP ☑ ALUM ○ ACSR ○ COMP. NO. 2180

O. D. MINIMUM .357 NOMINAL .360 MAXIMUM .363

WALL THICKNESS MINIMUM .0563 NOMINAL .0625

RUNNING DATA

AVERAGE O. D.

NOM. .360

REEL NO.	1	2	3	4	5	6	7
	7109	7110	7111				
MIN. WALL	.060	.061	.059				

MACH. NO. 1 SIGNED Al Teola (OPERATOR) 6304 (NUMBER)

PROCESS INSPECTION DATA

REEL NUMBER	1	2	3	4	5	6	7
AVG. O. D.	.361		.361				
MIN. WALL	.059		.059				
SAMPLE							

(Use reverse side for notes.) SIGNED [illegible] (INSPECTOR) 1772 (NUMBER)

Figure 1—Operator-Inspector Process Control Report

in costs. In this connection, we are constantly striving to create a quality-consciousness in the plant. Perhaps a slogan used by our company's founder as a closing sentence in letters to employees states the case best—"Rome Cable Quality Is in Your Hands." We try to convey as much information as possible about our product to each operator as the opportunities occur. This, we feel, is the one sure path toward maintaining desired quality levels at lowest cost.

Quality Control Methods at Work

Illustration #1. Perhaps one of the toughest single control problems facing the wire manufacturer is the problem of diameter control. The diameter limits for insulated wires are determined by industry standards, service, and quality requirements. We must operate at the most practical and economic level consistent with these limits.

The problem is a complex one because of many factors, some of which are:

- Variations among insulating compounds.
- Variations among insulating machines.
- Variations among insulating operators.

The above will be recognized quickly as the three M's—Men, Material, and Machines. For this illustration, we will try to show how one of our quality control tools is employed by the Men.

The insulating operation consists of applying a homogeneous mass of insulating compound concentrically around a conductor. It must be applied within certain dimensional limits for overall diameter and wall thickness.

QC – 500

ROME CABLE CORPORATION
ROME, N. Y.
QUALITY CONTROL INSPECTION SPECIFICATION

A. GENERAL

CUSTOMER _____ SAMPLING SPEC. NO. _____
CUST. SPEC. _____ DATE ISSUED _____
R.C.C. SPEC. _____ ISSUED BY _____
DESCRIPTION _____

B. INSTRUCTIONS

1. FOR CONTINUOUS PRODUCTION INSPECTION:
   A. EACH SUPPLY REEL SHALL BE INSPECTED FOR THE CHARACTERISTICS LISTED BELOW AT THE FREQUENCY INDICATED BY "X".
   B. IF A DEFECT IS FOUND IN ANY SAMPLE, EACH OF THE FOLLOWING LENGTHS FROM THAT SUPPLY REEL SHALL BE INSPECTED FOR THAT DEFECT.
   C. RECORD RESULTS OF INSPECTION ON FORM QC-101

CHARACTERISTICS	SAMPLING FREQUENCY PER SUPPLY REEL LENGTH NUMBER										
	1	2 / 12	3 / 13	4 / 14	5 / 15	6 / 16	7 / 17	8 / 18	9 / 19	10 / 20	11 / 21
Copper O.D.	X				X						
Lay of strand	X										
Min. Wall	X		X								
Average O.D.	X		X		X		X		X		X
Finish	X										
Packaging	X										

2. FOR LOT TYPE INSPECTION:
   A. SELECT RANDOM SAMPLES FROM THE LOT OFFERED FOR INSPECTION IN ACCORDANCE WITH THE FOLLOWING TABLE.
   B. IF REJECT NUMBER IS NOT EXCEEDED IN FIRST SAMPLE, PASS THE LOT. IF REJECT NUMBER IS EXCEEDED, TAKE A SECOND SAMPLE.
   C. IF TOTAL REJECTS FOUND (1ST + 2ND SAMPLE) DOES NOT EXCEED REJECT NUMBER FOR 2ND SAMPLE, PASS THE LOT. IF REJECT NUMBER IS EXCEEDED, THE LOT SHALL BE REJECTED.
   D. RECORD RESULTS OF INSPECTION ON FORM QC-101

LOT SIZE	FIRST SAMPLE		SECOND SAMPLE	
	SAMPLE SIZE	REJECT NUMBER	SAMPLE SIZE	REJECT NUMBER
2 - 65	7	0		
66 - 180	15	0	30	2
181 - 300	25	1	50	3
301 - 500	35	1	70	4
501 - 800	50	2	100	6

Figure 2—Instructions and Sampling Plans for Final Inspection

For the most part, the machine capabilities are well within industry requirements. Cost and other factors, however, dictate that our sights must be set narrower if we are to operate at the most efficient level. We want to produce wire at the "target" diameter and with as little variation as possible.

The solution to this problem seems to lie in the accurate placing of the nominal or target diameter with subsequent emphasis on control. To obtain data and to maintain continuing surveillance on these operations, we have devised a process control report form that can be used for any one of our thousands of conductor and insulation combinations.

This form (see Fig. 1) is divided into two main sections. The top section is used by the operator and the bottom section by the Quality Control Department.

Prior to "setting-up" an order, the operator fills in the top section with pertinent information such as order number, amount, size, and most important, the dimensional requirements as stated on his work order. There are several reasons for requiring this paper work:

- By reading his work order and supplying this information on the form, the operator is conscious of the requirements and has them more clearly in mind as he sets up the job.
- By combining the necessary running information on one form at the machine, supervision and others have a ready check at the machine.
- Since these reports eventually are sent to the Quality Control Department, we have all the information needed for summary and study.

We try to emphasize the nominal or target diameter by providing a special box in the center of the form for this dimension.

After the set-up has been made, and the machine is running satisfactorily, the operator plots the variation in diameter in terms of plus or minus deviations from the nominal. The report is so arranged that up to five individual measurements can be recorded for each reel. One measurement for minimum wall thickness is required for each reel produced.

The space at the bottom of the report entitled "Process Inspection Data" is used by roving quality control inspectors. We do not require that each reel be checked by them under ordinary circumstances. Material is inspected and data recorded

by them according to machine performance. The spaces are so arranged that inspector data can be compared with operator data.

Strictly speaking, these reports are not control charts even though there is close resemblance. However, they have been prepared so that control limits, sampling procedures, etc., may be instituted if desired. As they are presently being used, the intention is to give the operator and supervision a visual clue as to how he is running relevant to specification limits.

Data obtained in this manner are summarized periodically for several reports. One, which is issued weekly, is distributed to insulating supervisors and presents the results for the week in terms of running deviation from the specified nominals. It also shows the percent of material run above and below the specified nominal.

These data are also used to compute machine capabilities. Since the data are originally obtained by the operators themselves, and the report checked by our quality control inspectors, we feel that it is both accurate and usable. Control limits and/or specification limits based on data thus obtained are realistic and easily understood.

Illustration #2. This illustration describes a phase of production which required the development of two types of sampling plans for one type of material.

The product itself, a high-quality, insulated hook-up wire, is produced in very large quantities. It is run in lengths of approximately 35,000 to 40,000 feet per reel at a high rate of speed—approximately 1000 feet per minute. These production reels are subsequently respooled onto shipping spools which contain 3000 feet. Final inspection is performed at this point but may or may not be simultaneous with the respooling operation. Hence, the need for two inspection plans. We call the plans now in use "Continuous Production Inspection" and "Lot Type Inspection."

Instructions for the use of either of these plans are detailed in a Quality Control Inspection Specification (see Fig. 2). The Continuous Production Plan which has proved to be very effective, works like this. The first length spooled off a large supply reel is inspected for all characteristics. Subsequent lengths are inspected for each characteristic at the frequency indicated by the X's in the sampling table. For example, lengths 1, 3, 5, . . . 19, 21 would be inspected for Average O.D. If a defect is found, 100 percent inspection is performed on the remaining lengths for that characteristic. Each new supply reel is considered a new lot.

The second part of this specification covers material held in lots for inspection. The sampling plans used are drawn from MIL-STD-105A.

The reporting form (QC—101) used by floor inspectors for this inspection is presented as Fig. 3. Part A is used for continuous production inspection, Part B for the lot type, and Part C for the record of rejects found under either type of inspection. We have found that this form is easy to use in the plant and that it lends itself very well to summary work.

Illustration #3. Since we use over 100 different types of rubber and plastic insulating and jacketing compounds, the routine physical testing performed by the Inspection Department is a large and difficult assignment. In order to maintain adequate checks and do it efficiently, the amount of testing must be governed by compound usage and performance. The sampling for this testing is further complicated because we never know in advance which compounds will be run and in what quantities. Our solution to this problem was to set up a combination sampling and control chart plan.

The sampling plan is operated as follows. We require that each operator cut one sample from each reel produced. This sample is tagged and identified as to order number, size, reel number, compound, etc. The samples are delivered to the Inspection Department each morning. There they are grouped according

QC—101

ROME CABLE CORPORATION
ROME, N.Y.
QUALITY CONTROL INSPECTION REPORT

F.O. OR SCHEDULE _____ DATE _____

CUSTOMER _____ INSPECTOR _____

DESCRIPTION _____

A. RECORD OF CONTINUOUS PRODUCTION INSPECTION

SUPPLY REEL NUMBER		1	2	3	4	5	6	7	8	9	10	11	12
NUMBER LENGTHS (____ FT. EACH)	INSP.												
	O.K.												
	REJ.												

AMOUNT: RELEASED _____ REJECTED _____

B. RECORD OF LOT TYPE INSPECTION

LOT SIZE _____ LENGTHS OF _____ FEET EACH.

1ST SAMPLE _____ -DEFECTS FOUND IN 1ST SAMPLE _____

2ND SAMPLE _____ -DEFECTS FOUND IN 2ND SAMPLE _____

LOT IS RELEASED ☐ REJECTED ☐

AMOUNT: RELEASED _____ REJECTED _____

C. RECORD OF REJECTS FOUND (INDICATE NUMBER FOUND FOR EACH)

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

OTHERS:

Figure 3—Form Used for Reporting Results of Inspection as Specified in Fig. 2

QC-114

STARTED 5/19/55
COMPLETED 5/24/55

ROME CABLE CORPORATION
ROME, N. Y.
PHYSICAL TEST DATA SHEET

COMPOUND 6008 INSULATION

TENSILE STRENGTH

SAMPLE	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
1	2231	2177	2136	2419	2222	2169	2272	1816	2058	2300
2	2290	2037	2222	2338	2109	2352	2307	2403	2211	2314
3	2231	2201	2268	2268	2143	2116	2358	2163	2254	2019
4	2135	2854	2307	2185	2358	2307	2464	2169	2205	2268
SUM	8887	9269	8933	9210	8828	9014	9201	8621	8728	9101
$\bar{X}$	2222	2317	2233	2302	2207	2253	2300	2155	2182	2275
R	155	117	171	234	253	183	94	517	196	411

$\bar{\bar{X}}$ = 2245
$\bar{R}$ = 310

CONTROL LIMITS

UCL = $\bar{\bar{X}}$ + .729 $\bar{R}$ = 2471
LCL = $\bar{\bar{X}}$ − .729 $\bar{R}$ = 2019
UCL = $\bar{R}$ × 2.282 = 707
LCL = 0

% ELONGATION

SAMPLE	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
1	300	275	285	275	250	275	375	285	275	260
2	285	265	260	275	260	260	260	275	275	250
3	250	250	260	260	260	235	275	275	250	285
4	275	260	235	250	250	285	260	300	275	260
SUM	1110	1050	1090	1060	1020	1055	1270	1135	1075	1055
$\bar{X}$	277	262	257	265	255	264	317	284	268	264
R	50	25	50	25	10	50	115	25	25	35

$\bar{\bar{X}}$ = 271
$\bar{R}$ = 41

CONTROL LIMITS

UCL = X + .729 $\bar{R}$ = 301
LCL = X − .729 $\bar{R}$ = 241
UCL = $\bar{R}$ × 2.282 = 94
LCL = 0

NOTES: 1. Memo sent on group 2 - Excessive Range

Figure 4—Physical Test Data Work Sheet—Insulations

to compound number and sampled according to the following table.

Lot Size	No. Samples
2 — 8	2
9 — 15	3
16 — 25	5
26 — 40	7
41 — 65	10
66 — 110	15

The samples which are selected at random are then tested and the results recorded on Form QC—114 (see Fig. 4). (It should be noted that all samples are held until the testing is completed. If failures are found, the remaining samples of the same compound are tested 100 percent and disposition of the material represented by these samples made accordingly).

This Physical Test Data Sheet is maintained concurrently with testing by the physical test inspector. This inspector does not summarize or calculate limits. At the end of each day he turns in the notebook of data sheets to the supervisor of physical testing for review. He also turns in a slip (Form QC—115, Fig. 5) which lists the compounds that were active on that day.

The person reviewing these data sheets does two things: (1) He plots on control charts the results for each new group of four, and (2) He reviews the individual test results. If failures are noted, he immediately completes Form QC—117 (Fig. 6). This report is distributed to the Chief Inspector, and to the Laboratory, Engineering, Production, and Quality Control Departments. Note that these forms have been designed to command immediate attention We use this type of "attention getter' sparingly and only where and when immediate action is required.

As our recording Form QC—114 indicates, we summarize all data at the completion of each ten groups of four and compute new control limits. These limits are extended on the individual compound control charts QC—116-1, (Fig. 7) for the next group of 40 samples.

Industry Standards and Statistical Quality Control

Much of the product we manufacture is produced to industry standards. These standards, which are written by various groups composed of suppliers and consumers, are designed to insure that the product of all manufacturers will meet certain minimum requirements according to the end use. These standards, or specifications, include requirements for constructional details, performance characteristics, etc. Many also include a section which describes how the inspection and testing shall be conducted.

Recently, the trend has been toward revising this part of these standards to take advantage of modern statistical quality control methods. Two examples of this will now be discussed.

Illustration #4. The American Society for Testing Materials publishes many standards for the wire indus-

QC-115

ROME CABLE CORPORATION
ROME, N. Y.

Q.C. ACTION MEMO

DATE 9/8/55

THE FOLLOWING COMPOUNDS ARE READY FOR PLOTTING:

4075	9746 Jkt	7340
7090	4590 Jkt	
3590	5050 Jkt	
6008	8400	
8929	9000	

Figure 5—Intra-office Memo (indicates compounds tested each day).

try. Specification B-1 covers hard drawn copper wire for electrical purposes.

This specification was recently revised to include statistical sampling plans for determining conformance of the wire to the dimensional, surface finish, and packaging requirements.

Unique, however, is the manner in which this standards body arrived at and set up the requirements for the tensile strength and elongation properties of hard drawn copper wire.

After a very careful and thorough study of individual supplier performance and industry requirements, minimum values for tensile strength and elongation were established. Lots of wire produced and inspected to this specification are considered acceptable if the average tensile strength for four specimens is not less than the appropriate value minus 400 p.s.i., and no individual is less than the appropriate value minus 1700 p.s.i. Determining acceptability for the elongation requirements works the same way except that the required value is reduced by 0.05 percent for averages of four, and by 0.20 percent for individuals in a group of four.

The significant point here lies in the manner in which statistical principles have been applied in a practical and workable way.

Note that this plan recognizes and allows for the variability of averages of four and the natural dispersion of individual values. The actual values

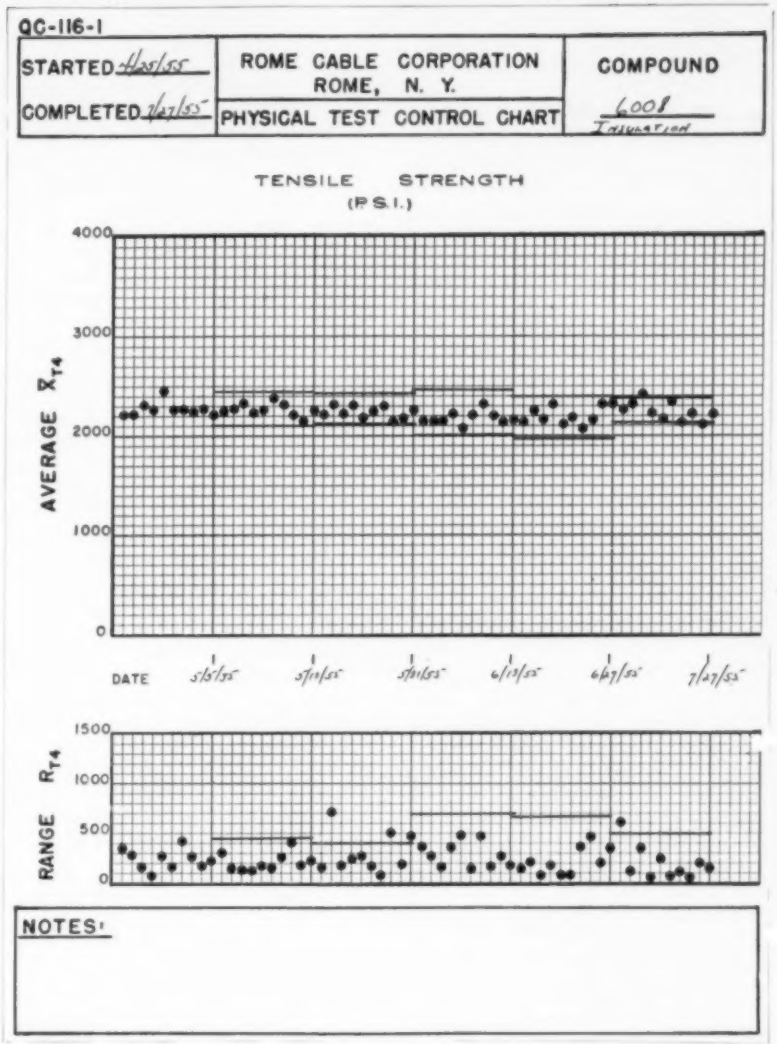


Figure 7—Physical Test Data Control Chart—Insulations

Q.C.-117

Q.C. **ACTION** MEMO

TO: A. G. Howe, Sr. DATE: May 13, 1955

FROM: Inspection Department SUBJECT: Initial Physical Test Results

Please note that test results for the following compounds are not normal for the reason indicated.

COMPOUND	REASON
6008	Excessive range for tensile strength values for four samples tested on above date. No Failures.

COPIES TO:
G. L. McCutchan
H. Howard
A. Woolley
C. K. Hamlin
R. C. Graham
E. M. Wolf
M. Williams
M. Kopchik
L. Selden
Engineering File

Felix Palombi
Inspection Department

Figure 6—Rejection or Sub-standard Product Notifications

used in this specification were developed from considerable data collected by the committee which revised this specification.

One important point should be noted—this is contained in the specification as Note 4, which reads as follows:

> Cumulative results secured on the product of a single manufacturer, indicating continued conformance to the criteria, are necessary to insure an over-all product meeting the requirements of these specifications. The sample sizes and conformance criteria given for the various characteristics are applicable only to lots produced under these conditions.

This instruction is a very important part of this plan since the efficiency of any good statistical sampling plan depends on the foundation on which it is built and the proper

use of a continuous record of performance data.

At Rome Cable we have found this plan very easy to follow. The Quality Control Department designed a form (see Fig. 8) for the orderly record keeping of test data. Figure 9 illustrates our method of plotting averages of four to provide a graphical record of test results. At the present time, we are not computing statistical control limits for these tests; the limits shown on the chart are specification limits. However, both the data sheet and chart are arranged so that they will be readily adaptable to statistical methods in the future.

These data sheets are maintained by the Inspection Department concurrently with the actual testing. This minimizes record keeping and assures that our cumulative history is always up to date. This, of course, also works to the advantage of the Chief Inspector and others interested in product performance.

Here again, we find that the application of quality control methods helps to streamline our inspection methods and, at the same time, make them more effective and useful.

Illustration #5. Another standards body, the Insulated Power Cable Engineers Association is also taking positive steps toward more realistic procedures through the use of statistical quality control methods.

A committee, composed of members of I.P.C.E.A., is making an exhaustive study in an effort to solve one of our most perplexing problems—determining acceptability of insulation walls.

Dimensionally, there are two basic requirements: (1) the insulation must be applied with a specified average thickness, and (2) it must be applied within specified concentric requirements. Presently, the concentric requirement is specified as a minimum dimension. For example, a specification may state that no measurement for minimum wall shall be less than 95 percent of the nominal wall for a 3/64 inch insulation.

In making the measurement a small piece of insulation is removed from the conductor, and acceptability is determined by the thickness measured at the minimum point. However, after making this measurement, we have little assurance that this one measurement is truly representative of the entire length. Inspection-wise, this one measurement has little or no significance, since the amount of variability is not known.

I.P.C.E.A. Project Committee #356 has been assigned this problem. For the past two or three years, this group has been collecting minimum wall data from several manufacturers. In summary, the data show that the process capability is approximately the same for all manufacturers. It also falls in a normal distribution pattern. This has made it possible for the committee to design a sampling specification based on statistical quality control principles.

Briefly, this inspection procedure provides for the orderly sampling from production lots. In conducting the inspection a sample of specified size is taken at random from the lot, and measurements of minimum wall are made on each specimen. The results are then totaled and the average determined. This value is then compared with the appropriate value in a sampling table according to lot and sample size. If the sample average is greater than the minimum value found in the table, the lot is accepted. If the sample average is

QC-105

PRODUCT #9 AWG Hard

ASTM (B-1) B-2 B-3

ROME CABLE CORPORATION
ROME, N.Y.
BARE WIRE DATA SHEET

DATE STARTED 2/7/55

DATE COMPLETED

TENSILE STRENGTH

LIMITS* NOMINAL – AVG. (4) 64300 MIN. – AVG. (4) 63900

MIN. – INDIVIDUAL 62600

TENSILE - P.S.I. $\bar{X}_4$

GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	65700	66100	64500	64100	64900	66100	65800	64600	65400	65000	64900	64600	64000			
2	64800	64700	64800	64400	64700	65800	65500	65000	64000	64100	65900	64400				
3	66900	65000	65800	65100	66000	65600	64600	65000	65200	64500	64600	64400				
4	66100	64800	65400	65900	65300	65400	64800	64200	63800	64900	65000	64600				
Σ	263500	260600	260500	259500	260900	262900	260700	258800	260200	258600	260400	258000				
X	65875	65150	65125	64875	65225	65725	65175	64700	65050	64575	65100	64500				

% ELONGATION

LIMITS* NOMINAL – AVG. (4) 1.02 MIN. – AVG. (4) 0.97

MIN. – INDIVIDUAL 0.816

% ELONGATION $\bar{X}_4$

GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.25	1.30	1.35	1.19	1.302	1.25	1.30	1.30	1.25	1.25	1.25	1.25	1.25			
2	1.25	1.09	1.45	1.25	1.19	1.30	1.35	1.25	1.09	1.25	1.30	1.30				
3	1.30	1.14	1.19	1.30	1.30	1.19	1.25	1.35	1.46	1.30	1.30	1.41				
4	1.65	1.20	1.25	1.30	1.30	1.25	1.30	1.77	1.46	1.19	1.25	1.30				
Σ	5.45	4.73	5.24	5.04	5.09	4.99	5.20	5.67	5.26	4.99	5.10	5.26				
X	1.36	1.18	1.31	1.26	1.27	1.25	1.30	1.42	1.32	1.25	1.28	1.32				

Figure 8—Physical Test Data Work Sheet—Bare Wire

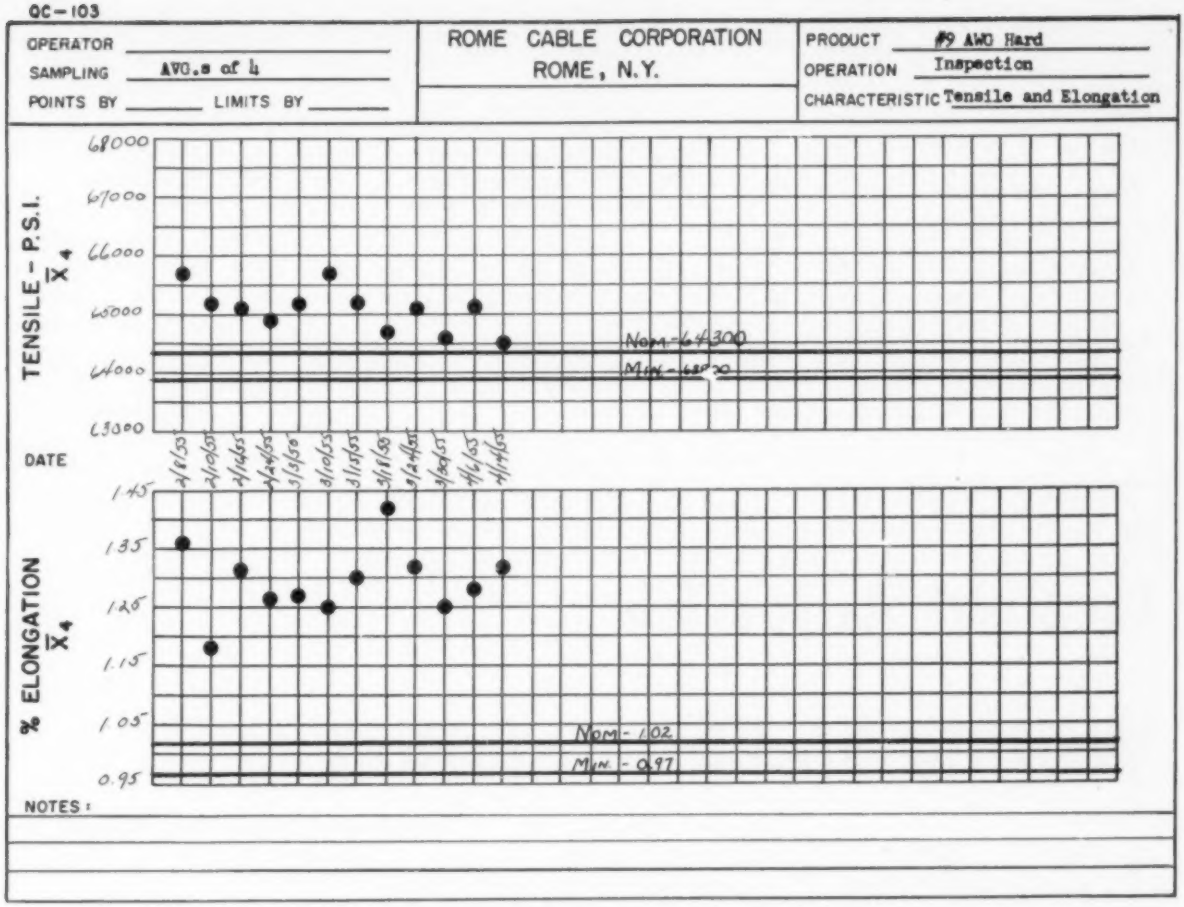


Figure 9—Graphical Record of Bare Wire Test Results

below this value, a second sample is taken and acceptability judged on the basis of this new average and the appropriate value in the sampling table. Rejected lots may be inspected 100 percent or reworked and reinspected.

In order to provide for changing machine capabilities, or changes in product performance, the sampling plans include other inspection levels which are based on a range of variability from 50 percent to 125 percent of the calculated normal standard deviation.

Although this sampling specification has not been adopted by I.P.C.E.A. as yet, it is now undergoing a thorough trial by several manufacturers. The committee feels that this trial will prove the value of this honest and realistic approach to the problem.

The foregoing illustrations serve to demonstrate two things:

- statistical quality control methods can be very helpful and effective in the wire and cable industry, and
- those responsible for the establishing of many of the industries standards are making significant progress in adopting statistical quality control methods to industry specifications.

Conclusion

We shall here re-emphasize several points that, to us as producers of quality wires and cables, are important.

- The use of quality control techniques can achieve success only when the people using them are sold on their value. We don't believe that we can, or should, set up plans in the front office, install them by edict, and expect to get very impressive results.
- In installing quality control plans in the shop, the machine operator must be made a part of the plan and must take an active part in the operation. Wherever possible, he should make the measurements and plot his own chart if one is used.
- Never underestimate the ability of the man on the machine. Rather, take a long look at your ability to get top performance from him. Engineering and science can provide the best possible equipment, inspection methods can provide rigid control of raw materials; results, however, will be satisfactory only if the *man* can be induced to turn in good performance. Nothing by the way of discipline or monetary rewards can come even close to stimulating the top performance he is capable of turning in if his interest in the end result is really aroused. The proper use of quality control techniques can help to arouse and hold this interest.

In short, don't lose sight of the goal just because you are equipped with reams of sampling tables and statistics. Quality of product is a characteristic built into the product

by the man, it cannot be inspected into a product—back him up and give him the best possible ammunition and tools to work with. After the engineering has been done, and the equipment provided, he is your greatest asset toward quality.

References

American Society for Testing Materials, *Specification for Hard Drawn Copper Wire B1-53T*

Insulated Power Cable Engineers Association, Project #356 Committee on Dimensional Tolerances

MIL-STD-105A

American Society for Testing Materials, *ASTM Manual on Quality Control of Materials*

Logical Rules for Writing and Interpreting Tolerance Specifications

FRANK PROSCHAN

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A great deal of disagreement exists in interpreting tolerance specifications. This article gives simple, logical rules for stating and interpreting tolerance specs.

Problem

How do you interpret tolerance specifications? Try the quiz in Table I. The correct answers are given at the bottom of page 17; they are "correct" in the sense of having been agreed to by many experienced people in the field who have given the problem thought. How do your answers compare?

If your answers do not all check with the "correct" answers, do not feel too badly. As a matter of fact, the results of this quiz, given to a number of Sylvania technical people, showed a great deal of inconsistency and disagreement. What then is an appropriate set of rules for writing and interpreting tolerance specifications?

Solution

Here is a simple, logical set of rules which subsequently will be justified[3].

1. Use the same number of decimal places to specify both the nominal dimension (the dimension aimed at) and the tolerance permitted. Thus, use 0.0761 ± 0.0023, not 0.076 ± 0.0023.

2. Consider a specification as a command which states:

   a. Measure the item specified to at least as many decimal places as in the spec.

   b. Round the measurement to the same number of decimal places as in the spec.

   c. Compare the rounded measured value with the spec. value.

   d. If the rounded measured value falls outside the tolerance band, reject the item; if it does not (i.e., if it lies within or at the extreme ends of the tolerance band), accept the item.

TABLE I—Tolerance Quiz
(Given by Alan A. Grometstein in the Electronics Division of Sylvania in 1951)

PART 1 Spec: 0.15 $^{+0.05}_{-0.00}$ inches			PART 2 Spec: 0.155 $^{+0.000}_{-0.004}$ inches		
PIECE	ACCEPT	REJECT	PIECE	ACCEPT	REJECT
1 0.205			1 0.1551		
2 0.146			2 0.1509		
3 0.21			3 0.156		
4 0.204			4 0.151		
5 0.145			5 0.1504		
6 0.15			6 0.1555		
7 0.20			7 0.155		
8 0.206			8 0.1511		
9 0.14			9 0.1505		
10 0.144			10 0.1558		

Rounding

The next question is: How do we round numbers? The preferred method is [1]:

- When one decimal place is to be discarded:

  A. If the digit in the decimal place to be discarded is 6, 7, 8, or 9, drop it and increase the preceding digit by 1. (0.176 ⟶ 0.18).

  B. If the digit in the decimal place to be dropped is 0, 1, 2, 3, or 4, drop it, and do not change the preceding digit. (0.231 ⟶ 0.23).

  C. If the digit in the place to be dropped is 5, then drop this 5 and

     a. Increase the preceding digit by 1 if odd. (4.75 ⟶ 4.8).

     b. Leave the preceding digit unchanged if even. (4.65 ⟶ 4.6).

- When two decimal places are to be rounded off, do the rounding *all at once*. Thus, 0.2349 becomes 0.23; 0.2351 becomes 0.24; 0.2350 becomes 0.24; and 0.2450 becomes 0.24. Clearly, the rule is to round *up* when the number in the two places to be dropped is greater than 50; use rule C. just above when 50 occurs in the two places to be dropped.

A similar procedure applies for rounding off three or more decimal places at a time.

Justification

The main idea back of the set of rules given is that a spec. is essentially to be used to decide *on the basis of a measurement* whether any particular piece conforms to a requirement. Since all measurements have some lack of precision, the spec. must designate the number of significant figures needed in the measurement.

(1) The reason for using the same number of decimal places for both the nominal dimension and the tolerance is this: Suppose, as in the example given, we wrote 0.076 ± 0.0023. The fact that 3 is given in the fourth decimal place would imply that the tolerance band is to be specified to the fourth decimal place. However, giving 0.076 to only three places means that the tolerance band could be anywhere from 0.0755 ± 0.0023 to 0.0765 ± 0.0023. In other words, the tolerance band is not actually specified to the fourth decimal place. This sort of inconsistency is prevented by Rule 1.

(2a) The reason for requiring that the item specified should be measured to at least as many decimal places as in the spec. is this: Suppose that the spec. is 0.076 ± 0.002. If a particular piece is measured as 0.08, how can we tell whether the piece is actually 0.075 or 0.084? In the first case, it would be accepted, in the second, rejected.

(2b) The measured value should be rounded off to the same number of decimal places as in the spec. because the spec. and the measured value are to be compared *on the basis of the number of decimal places in the spec.*

As for rounding, the only explanation needed is that of rounding off a place occupied by a 5. The rule given above is preferable to the alternative one of always rounding *up* because it does not tend to result in bias. According to our rule, we can expect that, on the average, half the time we would round *up*, the other half we would round *down*.

Borderline Cases

Consider the spec.: 0.155, +0.000, −0.004. According to the rules under Solution, a measurement of 0.15550 would be rounded to 0.156, and therefore the piece would be rejected; on the other hand, a measurement of 0.15549 would be rounded to 0.155, and therefore the piece would be accepted. In other words, two pieces differing by as little as 0.00001 would receive different treatment, one piece being summarily rejected, the other being welcomed into the fold of acceptable units. Is this not defying common sense?

The answer is that a specification, by its very nature, is an attempt to draw a razor-thin line between acceptable and unacceptable units of product. The thinner the line drawn (i.e., the more specific the spec.), the more satisfactory is the specification. A well written specification should leave as little as possible to individual judgment—should define as clearly and specifically as possible the criteria by which the inspector is to separate the unacceptable from the acceptable. In other words, the *designer* of the product (the specification writer) should assume the responsibility of defining the difference between good and bad units of product, rather than the *inspector* (the specification enforcer).

Setting the Gage

The discussion thus far has been in terms of *measuring* the units of product. Suppose, however, the inspection is conducted with a go, no-go gage. How should the gage be set?

Specifically, suppose the spec. is stated as 0.155, +0.000, −0.004. Naturally, the gage itself will have to be set with greater accuracy than the 3-place accuracy called for in the specification. Should the go gage be set at 0.1546, 0.1550, 0.1555, or what?

The sensible answer is to set the go gage at 0.1555. A piece unable to pass through the go gage set at 0.1555 would be larger than 0.1555 (the probability of the piece being identically equal in size to the gage is considered to be zero), and would therefore be unacceptable according to the rules under Solution. On the other hand, a piece slipping through the go gage would have to be less than 0.1555, and would, therefore, be acceptable. Thus the go gage setting of 0.1555 would permit a rigid enforcement of the rules under Solution for an upper limit spec. of 0.155.

To generalize, the go gage should be set at the midpoint of the decimal place following the last decimal place of the upper spec. limit. From similar considerations, it follows that the no-go gage should be set by first subtracting "1" from the digit in the last decimal place of the lower spec. limit, and then inserting "5" into the following decimal place. (Thus, the lower spec. limit of 0.151 is enforced by setting the no-go gage at 0.1505.)

Fractional Tolerances

What happens now if the specification is written in the form of a fraction, such as $2\frac{3}{16}$ inches? In this case, "no limits need be placed on fractional dimensions because their use indicates that the practical accuracy with which a sixty-fourth scale can be read (± 0.010) is acceptable as the tolerance."[2] If greater accuracy is required, then the specification should be written in decimal form, rather than in fractional form.

Conclusion

A good deal of unnecessary confusion and contradictory interpretation of specifications may be avoided if the rules for writing and interpreting specs. presented under Solution in this article are followed.

Problem Answers

Here are the correct answers to the problem in Table I. For Part I: accept—1, 2, 4, 6, 7; reject—3, 5, 8, 9, 10. For Part II: accept—1, 2, 4, 7, 8; reject—3, 5, 6, 9, 10.

References

(1) American Standard Association, *Rules For Rounding Off Numerical Values*, ASA No. Z 25.1, 1940

(2) *Kent's Mechanical Engineers' Handbook*, Design and Production Volume, Twelfth Edition, 1950 ,p. 24-02

(3) MacNiece, E. H., *Industrial Specifications*, John Wiley & Sons, Inc., N. Y., 1953, p. 55

Statistical Quality Control

Applied to Precision Manufacture of Weapon Barrel

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Introduction

This article reports the case history of a statistical quality control application. It outlines the need for sound controls, the actual installation of such controls, and the direct savings derived therefrom.

The direct savings in time and material, as well as improved relationship between production and quality control personnel have been of such magnitude as to demand expansion of the program to include all units of the company.

Background

The Line Material Industries, at its Southern Plant in Birmingham, Alabama, had been producing rifle barrels under a contract with the United States Government, Army Ordnance Department, in connection with the manufacture of the U. S. Rifle Cal. 30 M-1, commonly known as the Garand. The Garand rifle is a semi-automatic, gas-operated, shoulder weapon with all parts interchangeable and of close dimensional tolerance, the barrel of necessity being one of the most exact.

In June of 1953, The Line Material Industries entered into a production contract for the M-1 barrel, after successfully providing a complete facility for its manufacture and obtaining approval of a pilot lot from the Springfield Armory at Springfield, Mass.

In the manufacture of the barrel, there are 59 machining operations with some dimensional tolerances as small as minus 0.0005 inches. With production of 32,000 pieces per month on a two-shift basis, it can be understood that barrels proceeding from one operation to another should necessarily be of uniform characteristics. They should be kept as "a group, produced by the same method, to the same dimensions, and in succession." In other words the groups should be "homogeneous."

One-hundred percent inspection was applied to all finish dimension machining operations, which actually meant trying to sort the good from the bad. The good pieces were being allowed to proceed and the out of tolerance pieces being held for further screening, and either rework, or disposal as scrap. This practice therefore, rendered it impossible to keep production homogeneous.

With the volume of work required in the line for schedule compliance, plus all the barrels which were held back for rework or disposal, a total in-process inventory far in excess of that required to maintain schedule was on hand. With this excess of in-process barrels throughout the line, it can be understood that even the most rigid control over defectives would be unlikely to prevent some from filtering back into the line and ultimately arriving at Ordnance Inspection.

The contract progressed for several months with Ordnance Inspection receiving barrels in lots and employing their regular acceptance sampling plan, for acceptance or rejection. This practice, plus the fact that the individual lots were made up of barrels which were not homogeneous, resulted in an accumulation of unacceptable barrels at our final inspection area. These accumulated barrels were rejected for various defects, and after screening, were re-submitted, with some lots going to a fifth submission before acceptance.

Acceptance by Ordnance Inspection by lots was as follows:

1300 barrels per lot.
143 lots submitted—totalling 187,000 barrels.
21 percent accepted on first submission.
57 percent accepted on second submission.
22 percent accepted on third, four and fifth submission.

The extent of the sweat and tears expended in obtaining acceptance of the 143 lots can be easily understood from the above figures, to say nothing of strained relations between production and inspection resulting from inconsistencies of methods.

SQC Needed?

Among the supervisory group in the Barrel Department, there were several persons with a limited knowledge of statistical quality control who saw the need for a system that would insure control, and relieve the congested condition. Statistical control was recommended and immediately the entire manufacturing process was reviewed and found to be readily applicable to statistical methods and techniques, using attributes in some instances, and $\bar{X}$ and R charts elsewhere.

Machine studies were made, consecutive pieces from each machine were measured, and capabilities computed. It was astounding to find that the actual capabilities of some of the machines exceeded previous maximum expectations. As data were gathered, control levels were set on each operation, taking into consideration the part each played in regard to succeeding operations, and how critical it was in regard to the finished piece.

During this period, a review of all methods of measuring and gaging was necessary. The initial facility employed fixed type gages of the "go" and "no-go" type for production line inspection, in most cases, and since control charts of the $\bar{X}$ and R type were being placed along the entire line, direct reading gages were necessary. Upon reviewing the entire process, evaluation of each operation and its dimension was made. Then, having given consideration to the capability of the machine furnished to produce this dimension, the decision as to the type of measuring device or gage to use was made.

Establishing Process Controls

The entire production line, when completed after this review and evaluation, appeared as follows:

1. On unfinished, and qualifying dimensions; i.e., chucking surfaces and steady rest surfaces, "go" and "no-go" fixed gages for lengths.
   Simple attribute charts were kept at these operations, from samples taken at regular time intervals, computed from the data gathered in the capability studies.
2. On finished machining dimensions, finish grinds, finished cut lengths, etc., indicator type snap gages or column type air gages were used to check diameters, and indicator type length gages for checking lengths.
   $\overline{X}$ and R charts were placed on the finished operations and average and range recorded at regular time intervals, as prescribed by data gathered from the capability studies. ($\overline{X}$ and R charts illustrated in Fig. 1). The $\overline{X}$ and R charts used on the finished machining operations were modified to show in addition to control points, the tool wear of the cutting tools.

By using the modified chart as explained above, and being able to spot trends in cutting tool wear, re-setting of tools could be accomplished before any defective pieces were produced.

In cases where inspection found that an operation had gone out of control within the inspection time interval, all barrels produced by that operation since the preceding inspection check were screened 100 percent. This procedure quickly removed the possibility of appreciable accumulation of rework pieces, and those that were accumulated which could not be remedied and placed back in the line during the same shift they were produced were allowed to proceed as a special lot, designated as such by colored dolly cards.

To explain the colored dolly cards, the card system was set up to differentiate between barrels with known deviations and any others. Production was clearly marked by the use of the dolly card color code, as to where uncontrolled barrels ended and controlled barrels began. When controlled production began arriving at our final inspection, lots selected for submission to Ordnance Inspection were homogeneous, and immediately began to indicate the benefits that could be expected as the system was further proven.

As the controls on different operations were tried and proved, a complete inspection operating procedure was written for each. These procedures covered the actual inspection procedure, time intervals of inspection, gage lists and their operation, and complete information on control charts and their maintenance. Special features of the system, such as the dolly card color code, were also put in written procedure form.

When the procedures were finally edited, they were reviewed by all concerned before distribution. Training meetings were held to insure familiarity with all phases such

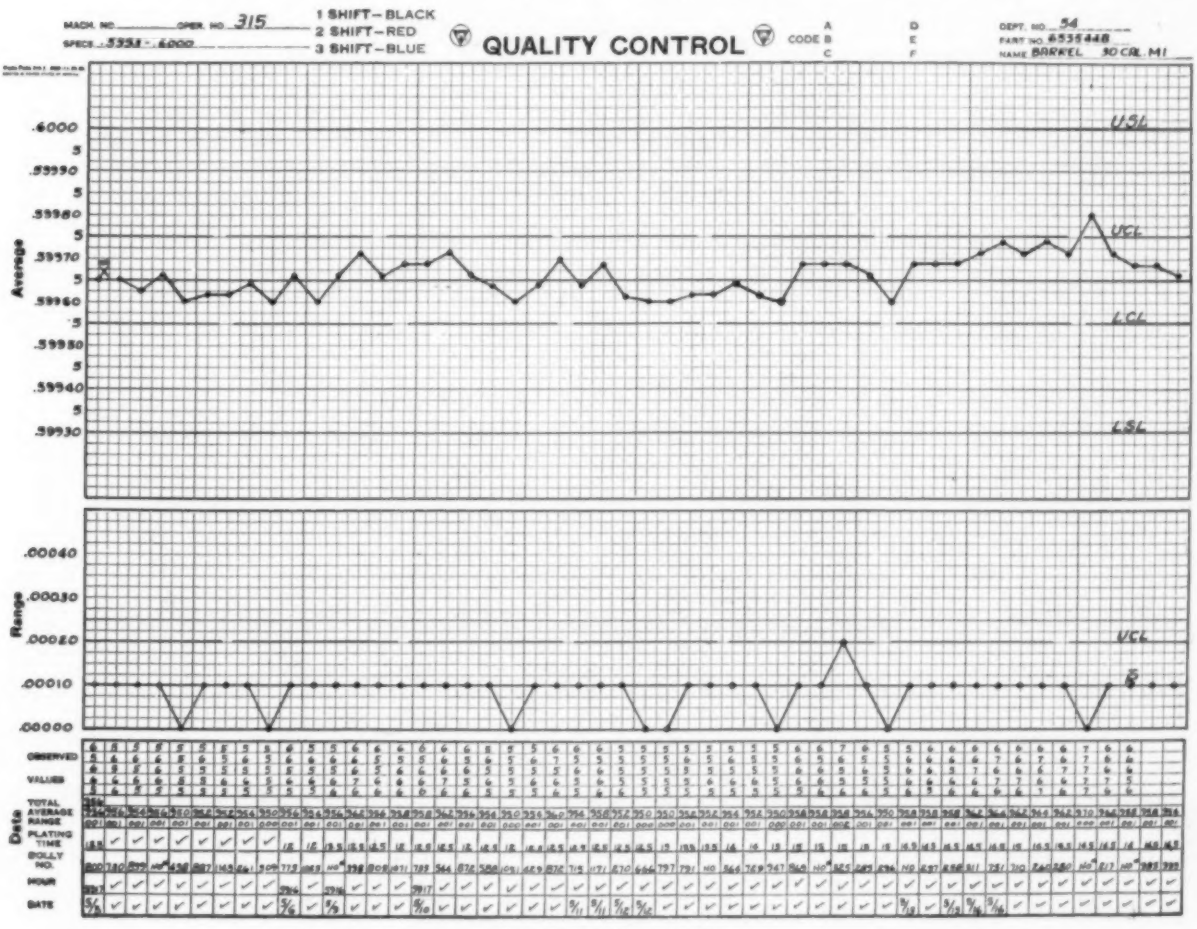

Figure 1—$\overline{X}$ and R Chart

as machine charts, methods of measuring, sample sizes, and other details.

The psychological effect on the production personnel was very noticeable as the charts were used more, because they seemed to realize that the chart was somewhat of their report card, placed at their machine, pointing to their individual performance. In a few cases when points indicated that a change in set-up should be made, and the set-up man indicated that nothing could be done, the operator demanded that change be made or else it would be pointed out on the chart that his performance was lagging.

Final Inspection Controls

Ordnance final acceptance is based on a regular MIL-STD-105A Double Sampling Plan. This plan is employed to inspect the 59 characteristics outlined on the Component Inspection Procedure, or C. I. P.

The characteristics on the C. I. P. are classified as criticals, majors, minors, and incidentals and have Acceptable Quality Levels or AQL's of 0.65 percent for criticals, 1.0 to 2.5 percent for majors, 4.0 percent for minors, and 6.5 percent for incidentals. The sample is selected at random, according to the number prescribed by the sampling plan. The sample is inspected for each characteristic on the C. I. P., and accepted or rejected per acceptance numbers on the sampling plan under the defects AQL.

If the lot is accepted on the basis of the sample, it is 100 percent inspected for visual defects and missing operations. Throw-outs due to this visual inspection are returned to contractor, are remedied and placed back in the same lot, or if the number is great enough, accumulated and submitted as a separate lot. If the lot is rejected on the basis of the sample inspection, the entire lot is returned to the contractor and screened 100 percent for defect or defects rejected. The lot is then resubmitted as the same lot, second submission. This repeats on each rejection until the lot passes the desired AQL.

From this explanation, it can be understood that some final control was needed to assure the quality level being turned over to Ordnance Inspection.

An acceptance sampling plan was installed at our final inspection department. The sample selected was approximately twice as large, and with only one-half as many defects allowed as Ordnance MIL-STD-105A. The same C. I. P. was followed and the same characteristics were checked, using gages and measuring equipment maintained at the same dimensions. It was felt that with such a plan, if the sample passed our acceptance inspection, acceptance by Ordnance would be insured since we were using a stricter plan.

Percent defective charts, commonly referred to as p charts, were made up for each characteristic, and from our final inspection reports the percent defective was plotted in red on the p chart. When Ordnance sent its inspection reports to us, the percent defective found by its inspection was plotted in black on the

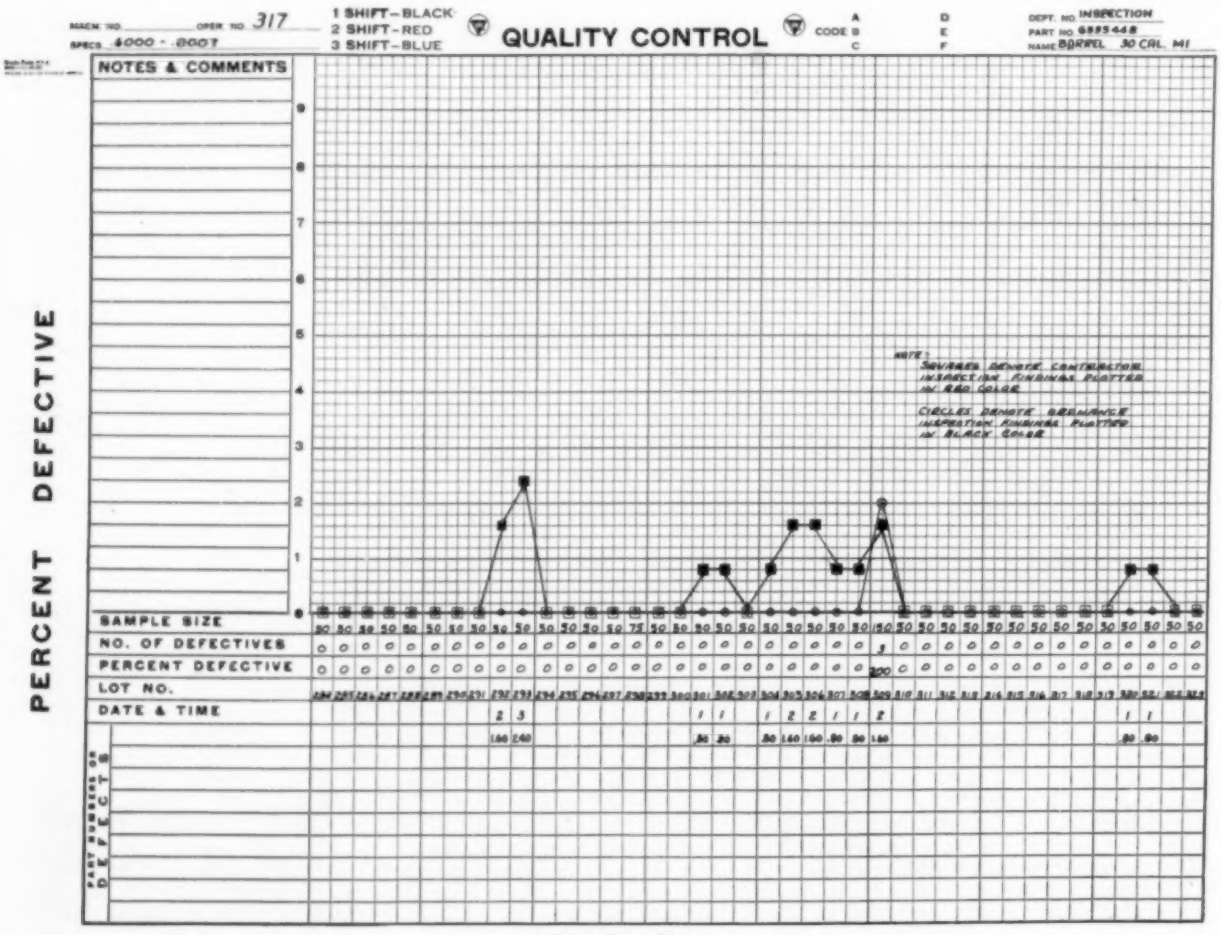

Figure 2—p Chart

same p charts (p chart illustrated in Fig. 2). With the aid of these charts, it was possible to concentrate on troublesome points of inspection. If Ordnance percent defective was greater than ours, it pointed directly to a possible trouble spot and was an invaluable aid in training inspection and pointing out weaknesses.

SQC Produces Results

When all the aforementioned controls were installed and maintained throughout the production line, the change was overwhelming. Performance in acceptance improved by leaps and bounds and causes of defects could be traced as far back on the line as desired. Any questions as to what part of the in-process material was affected could be clearly pointed out with records to prove it.

Performance in acceptance after controls were started were as follows:

1300 barrels to lot.
300 lots submitted—totalling 390,000 barrels.
80 percent acceptance on first submission.
19 percent acceptance on second submission.
1 percent acceptance on third submission.

It is interesting to note that the probability of submitting a lot of barrels to Ordnance and having it accepted without a single defect being found is approximately one in 5000. Since controls have been installed, there have been three such lots on this contract. There were also several months that acceptance on first submission was 100 percent.

The controls explained here were set up with the technical help that was available in our existing personnel, in a minimum of time, and with no interruption in production. With regard to savings realized—first and foremost, acceptance became virtually certain with the introduction and maintenance of controls. Improved relations between inspection and production were realized, as soon as it became evident to them that there *were* clear-cut answers to many of the problems which had been plaguing both departments. Savings were realized with the continued improvement of rework and scrap figures. The inspection force was reduced from 40 persons to 26 on a two-shift basis.

Conclusion

The Line Material Industries' Southern Plant produces pole line hardware for electrical distribution systems and street lighting equipment. It is one of nine plants situated throughout the United States, including one in Canada. The other eight plants make a full line of electrical transmission and distribution equipment such as transformers, lightning arrestors, fuse cutouts, oil circuit reclosers, hi-voltage switching equipment, street lighting, and underground electrical equipment.

The Southern Plant's normal line of manufacture is a far cry from the precision piece which is the M-1 barrel. However, since the barrel line has been controlled and the improvement and savings evaluated, it has been requested that controls be instituted throughout the remainder of our manufacturing process. Much of this expansion has been accomplished and is operating to the continued satisfaction of all concerned.

With further regard to statistical quality control as applied to the precision manufacture of the Cal. 30 M-1 barrel, it is, of course, enthusiastically received by the U. S. Government. Having been tried and proved on this operation, it has been recorded in every detail, in writing, and is a firm part of the operational procedures. There is little doubt that if and when new contracts are let for this item by the Ordnance Department, they will demand of the contractor that firm statistical quality control procedures be adhered to in the manufacturing processes.

Application of Statistical Quality Control in Glass Fabrication

T. R. MEYER, J. H. ZAMBONE, F. L. CURCIO

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Kimble's Quality Organization

Kimble makes a varied type of glass product including television bulbs, glass containers, bottles, scientific apparatus, tubing, electronic glassware, hand-blown ware, insulators, and structural glass block. There are five plants in our company located in Illinois, New Jersey, Indiana, and Ohio.

The manufacturing processes of Kimble are basic with the industry and are of two types: (1) the glass tank—fabrication directly from the glass tank, lehring, and inspection; and (2) fabrication from a base material such as tubing or glass blanks, lehring and inspection.

In the quality control organization there is a director of quality who is a member of a staff department (Kimble Administrative) which reports directly to the manager and president of Kimble Glass Company, a wholly owned subsidiary of Owens-Illinois. Each of the plant quality control managers reports directly to his respective plant manager.

A standards department reports to the director of quality control. The function of this department is to maintain sales specifications where necessary and to

maintain uniform specifications and sample standards among Kimble plants. With several plants producing the same product, it is obvious that specifications, testing equipment, and quality control must be uniform and centrally controlled, so that quality emanating from the several plants will be equivalent. This central control is a responsibility of the director of quality control.

In one of our plants more than 16,000 different items are produced. Small glass containers, scientific and laboratory ware, tubing and many other glass products are made by many varied operations. The nature of this material is such that it has always required inspection. Prior to SQC this inspection consisted either of 100 percent inspection of the finished product, which is costly and not always efficient, or "spot checking," which guaranteed very little of anything.

A number of years ago, management investigated statistical quality control and its possibilities. As a result of this early interest and full cooperation throughout its development, quality control has grown so that today we are covering all the plants by process control, and most of our outgoing products by sample inspection.

The sampling practices we use are standard ones. Before most of our ware enters our warehouses, it is subjected to quality control sampling inspection. Inspectors in our packing areas draw random samples in accordance with Military Standards sampling plans from lots which may consist of one or every carton. Accepted lots are stamped with a quality control stamp and are sent to the shipping areas. Rejected material is returned to the packers for reselection after which it is once again sampled.

There is no doubt that the two programs, process control and sampling inspection, have contributed to improvement of product. This improvement has been made concurrently with reduction of waste and rework during operation. Every day we find new ways to apply statistical methods. Some of these applications are outlined here.

Special SQC Applications in Glass Fabrication

Applications of statistical quality control in our particular phase of the glass container industry are many, and we are continually using more and more of the available tools to make our operations more efficient and better controlled. Examples of various techniques we have used are as follows.

1. Setting of Specifications. Recently our ampul fabricating machines were all replaced with new models which represented a substantial improvement over the old. In the pilot trials of the first new machine, the quality control department maintained $\overline{X}$ and R charts on every dimension of the ampuls. On the basis of frequency distributions made from in-control operation, specifications were established by means of tables published on "Tolerances of the Normal Distribution" in the Columbia University Statistical Research Group's *Techniques of Statistical Analysis.*

These tables furnish K-factors for $\overline{X} \pm KS$ (where $\overline{X}$ is the sample average, and S is the sample standard deviation) which gives the desired upper and lower tolerance limits. The K values are more than just normal deviates, for they depend on the sample size, the probability desired, and the confidence desired in setting the tolerances. They allow for the fact that the sample average and sample standard deviation may differ from true average and true standard deviation by amounts dependent on the size of the sample used in the computation of the sample statistics. The specifications calculated on the basis of the pilot runs have withstood the acid test of production conditions and have been published as our official specifications.

2. Establishment of Cutting Lengths. Another class of vials which we make is one which is basically a short piece of glass tubing with a tooled finish on one end and the other end either open or "bottomed." Ordinarily the sequence for the manufacture of such an item is:

- "Pulling" tubing from a glass furnace and cutting it to five foot lengths. The tubing is then sorted to a specified outside diameter. Frequently, the tubing is retrimmed slightly to an exact length and further segregated by weighing it into various gram weight brackets.
- Recutting the tubing into shorter pieces. The cut length will depend on the size and shape of the ultimate finished product, and also on the particular weight bracket of the tubing being cut.
- "Tooling" a finish. An example is a screw thread on one end of the short piece. (We will suppose for simplicity that the other end is to remain open.) This tooling is performed on a machine which melts one end of the piece and then carries it through a tooling station which reshapes the molten glass into the desired finish.

On most of the items made in this fashion, close specifications for outside diameter and inside diameter of the finish, shape of the finish, and over-all length of the completed vial must be maintained. The problem, of course, is to properly determine the length of the original blank tubing in order that all specifications will be properly met. Such a problem is easily solved by trial runs with close $\overline{X}$ and R control charting of original cut length, all pertinent dimensions of the finish, and the over-all length of the completed vial. Appropriate analysis of these charts will then yield adjustments which may have to be made to the cutting length used on the trial run.

Analysis of these charts will also yield necessary information for calculation of cutting lengths for tubing with a slightly different average cross section or weight. More advanced mathematical methods based on theoretical calculation of volume of glass necessary for the finish above have also been used, particularly for the initial determination of trial cutting length. Trial runs are then made to verify the theoretical calculations as well as to aid in the precise designing of the necessary "tools" to make the ideal finish.

In actual production, appropriate $\overline{X}$ and R charts (or narrow limit gage charts) on the critical dimensions are maintained. Adaptations of narrow limit gage control charts have been in use in various departments of our plant for several years, and have been enthusiastically endorsed by production people. From our point of view, we consider them superior to equivalent standard $\overline{X}$ and R charts for certain operations. They have actually resulted in better stability of dimensional control, since machine operators may easily find for themselves, without pencil or paper or calipers, that they are in or out of control during the in-between times when quality control inspectors are at other machines.

3. Acceptance and Rejection with $\overline{X}$ and R Control Charts. In the case of destructive testing in glass, the $\overline{X}$ and R chart control is most helpful in minimizing the use of variable sampling plans and eliminating the use of the uneconomical attribute sampling plans.

In Kimble we have two excellent examples of such a control in our scored ligature tubes and our color break

ampuls. In both cases the glass is eventually broken in two in the operating room or the doctor's office for the easy removal of the sutures or liquid medicines. The glass must be so controlled in breaking force that it will process and ship without breakage, but at the same time break readily by hand when bent in the proper manner by the eventual user.

A reliable tensile strength tester is used to break and record the breaking strength. Checks are made on the process at half-hour intervals plotting the average and range on a standard $\overline{X}$ and R chart. Process capability is determined during a closely controlled period prior to "freezing" the control limits.

Sample sizes greater than the conventional four or five are used to determine more accurately the true average breaking strength and thus reduce the error of indicating in-control averages when the average is actually out of control. To augment this, rules that depend only on extreme runs are followed to detect a shift in average; i.e., check for assignable causes whenever: *

- Seven successive plots fall on one side of the central line.
- Of eleven successive points on the control chart, at least ten are on the same side of the central line, etc.

When one plot falls outside the control limits, the ware made in the previous half-hour period, as well as ware made until correction has been effected, is quarantined.

In this case where destructive testing was necessary and a range in breaking force had to be maintained, the $\overline{X}$ and R chart has been powerful in producing a well-controlled item which without such control would have been one of questionable nature.

4. Strength Testing of Special Glass Containers. In the previous example, we presented the application of $\overline{X}$ and R control charts in cases where destructive testing was applied. Frequently, it is desired that ware rejected on the basis of the control chart (or held in stock) be sampled for breaking strength. In such cases a variable sampling plan based on standard unknown-sigma schemes is used.‡ A particular sampling plan has been chosen which has an operating characteristic curve closely matching that of the $\overline{X}$ and R control procedure used in the original process on the item.

5. Variation of Breaking Strength Due to Dimensional Factors. In the early development of the special glass containers mentioned above, it was desired that the amount of variation of breaking strength associated with various dimensional variations at the breaking point section be determined.

As a first approximation of the relationship of breaking strength to these various dimensional characteristics, a linear multiple correlation involving four variables, three dimensional (independent) variables, and the breaking strength was used. With standard least squares techniques, the various effects of each independent variable on the breaking strength were determined and the "coefficient of multiple determination" was calculated to give the joint association of all the independent variables with the breaking strength. The answers obtained in this study proved invaluable in pointing the way toward stabilized control of the breaking strength of the special container.

6. Predicting Yields with Various Tube Sorting Schemes. Ordinarily, glass tubing during the pulling operation is cut to four foot or five foot lengths and then sorted to a specified outside diameter range. This sorting may be done by just gaging one point at a specified distance from the end of a tube; two points, each at a specified distance from each end of the tube; or the entire length. For a specified O.D. range it is frequently desirable to know what effect on the percent yield of "good tube" the various sorting schemes will have. Since tubing is not perfectly uniform for O.D. throughout a particular five foot length, the yield will reduce as more points within any particular length are required to be within a specified O.D. range, and will be least when all points are required to be within that same range of O.D.

In the case of one-point sorting, we have a simple application of univariate normal curve probabilities using the mean and standard deviation of the outside diameter. These statistics can readily be determined by frequency distributions from $\overline{X}$ and R charts which are based on random O.D. measurements.

For two-point sorting, we must use bivariate normal distribution theory where the two points measured may be assumed to have the same mean value and standard deviation and are also correlated. These various statistics may be determined from a sample; and after suitable mathematical calculations, circular probability paper* can be used to determine the percent yield.

For all-point sorting, we again may use the bivariate normal distribution. In this case the calculations are based on the distributions of the maximum diameter within tubes, the minimum diameter within tubes and the correlation of the maximum O.D. with the minimum O.D. Again, the circular probability paper may be used to avoid integration of a probability integral.

7. Predicting Pack With Use of Prediction Limits. One of the difficult problems in a glass process where annealing immediately follows fabrication is the inability to determine defects quickly in order to take immediate corrective acton. The annealing process takes from one to over two hours. First inspection had to wait until after annealing when it is cool enough to be inspected easily.

To obtain earlier data a "hot inspection" was introduced between fabrication and annealing, but it wasn't until the prediction limit system was introduced that better results were secured. The quality control inspector was now able to predict the pack one to two hours ahead of the 100 percent screening, thus permitting corrective action at the forming machine if the prediction limits so indicated. The efficiency of the 100 percent inspection was also checked against these limits. The calculation of the prediction limits was based on the inverse solutions of the incomplete Beta-function as discussed in the *Engineer's Manual of Statistical Methods* by Leslie E. Simon.‡

8. Continuous Sampling for Thermal Shock Testing. The thermal shock test of glass consists of heating up the glass in a hot bath and then plunging the glass into a cold bath. A reverse thermal is also used depending on whether the suspicion for the break sources is on the outside or inside surfaces. Correlation of the severity of the thermal shock with field experience is also a requisite in establishing the proper test.

Results Benefit Both Kimble and Its Customers

After a solid foundation had been built through exposure to the new methods, we began to present talks and programs on quality control. These programs were

*E. L. Grant, *Statistical Quality Control*, second edition, McGraw Hill, New York, 1952, p. 113.
‡See *Sample Inspection by Variables*, by Bowker and Goode, McGraw-Hill, New York, 1952.

*See "Circular Probability Paper" by Leone and Topp, *Industrial Quality Control*, Vol. IX, No. 3, Nov., 1952.
‡Also see "Control Limits for Visual Quality," *Industrial Quality Control*, Vol. X, No. 6, May, 1954.

directed, not only at plant supervision on all levels, but to groups of our salesmen. We feel that these presentations have had a great deal to do with the enlightenment and subsequent acceptance of our concepts by the men with whom we work. Our salesmen, through their course of instruction, are better qualified to discuss quality with customers. Quality control in turn benefited from this in that we obtained more factual information from the field concerning customer requirements.

As a result of our experience with statistical quality control, several things have been accomplished. The first of these is the reduction of the amount of 100 percent inspection and gaging. Quality control at the process proved that operation in many cases was good enough to permit sampling of the final product. When this was attempted, results were extremely gratifying; by development and expanded application of this program we have saved thousands of dollars and have at the same time guaranteed an even better product to our customers.

Another result of SQC has been a noticeable reduction in customer complaints. The trend has been steadily downward ever since our sampling inspection of outgoing ware became firmly established. One definite aim of quality control has been to foster harmonious thinking on quality with our customers. We have held meetings with many of these customers to establish limit samples agreeable to both vendor and consumer. We have encouraged customers to tell us exactly what they want and expect to get. With this knowledge our inspection position has been strengthened and a much sounder inspection procedure has grown.

FROM THE SCRAP BOX

MASON E. WESCOTT, *Editor*

A Simple Iterative Process for Square Root Extraction With Desk Calculators

JULIAN H. TOULOUSE

Owens-Illinois Glass Company, Toledo, Ohio

When a difference between the roots of two numbers is desired, it may be necessary to determine the roots to more than four significant digits, the usual limits in many tables. There are some detailed methods of calculating to five places, but a table and synopsis of the method must be available. One machine can be had which determines square roots, but it may not be available when the need is infrequent. Finally, one may calculate the square root by a rather slow, and elaborate scheme, in which a single error, unchecked, may cause much embarrassment.

This article outlines a method which very quickly determines square roots to as many as ten significant digits, even without reference to a table as a starter. It is a very old method* in the history of arithmetic computations, but not a very practical one unless one has available a desk calculator to remove the labor of performing the divisions required. A good reference on the method may be found in Paul S. Dwyer's *Linear Computations*, p. 4-7, (Wiley & Sons, 1951.)

The method consists of dividing the number, whose square root we desire, by an approximate root, either from a table, or by inspection. The quotient is a second approximate root. The mean of the two is near the real root, but it can be used, as a second step, and as a new approximate root, to get a new second approximation. The mean of these new approximations is still closer to the true root.

*The precedent on the method is found on page 79, Chapter VI, Paragraph 42 of *The Calculus of Observations* by E. T. Whittaker and G. Robinson, Second Edition (1932) published by Blackie & Sons, London and Glasgow. The reference calls it "the principle of iteration" and refers to Rigaud's *Correspondence of Scientific Men of the 17th Century*, page 248. This source quotes a letter from Gregory to Collins, and independently from Michael Davy to Isaac Newton, and is of course a long time antecedent of the method presented in this issue of *Industrial Quality Control*.

Many may be familiar with the fact that (dealing for the moment with whole numbers) $(N - 1)(N + 1)$ differs from N^2 by 1^2, that $(N - 2)(N + 2)$ differs by 2^2, etc. This does not help us directly, but $(N - X)(N + Y) = N^2$ only when $(N - X)$ approaches $(N + Y)$, i.e., when X and Y each approach zero. Hence, the mean of $(N - X)$ and $(N + Y)$ approaches N by an even smaller difference. At any stage the mean is closer to N than either $(N - X)$ or $(N + Y)$. If we originally set $(N - X)$ very close to N, and correct it to the mean of $(N - X)$ and $N^2/(N - X)$, we can in a very few steps make the difference between $(N - X)$ and $(N + Y)$ as small as we please.

Example 1.

Stage 1.

a. Take any number, 1459782187 for example, whose square root is desired. Round this to $146000000 = (146000)(10^4)$.

b. In a 1-1000 table of squares, we find $(382)^2$ closest to 146000. Hence, the first approximate root is $A_1 = 38200$

c. Divide the original number by A_1 to get $A_2 = 38214.19340$

d. Add A_1 and A_2 and divide by 2 to get $A_3 = 38207.09670$

Stage 2.

a. Divide the original number by A_3 to get $A_4 = 38207.09536$

(It is now evident that we already have the root to 7 digits)

b. Add A_3 and A_4 and divide by 2 to get $A_5 = 38207.09603$

(This is a root to 10 places, the limit of the machine, and is certainly accurate to 8 or 9, possibly 10 digits)

Example 2.

Now suppose we had no table to start with. By inspection the root starts with the digit 3, and nearly 4. Although we could "guess" closer let's take 40,000 as the first approximation, A_1.

Stage 1.

a. Divide the original number by 40,000 to get $A_2 = 36494.55468$

b. Add 40,000 and divide by 2 to get $A_3 = 38247.27734$

Stage 2.

a. Divide the original number by A_3 to get $A_4 = 38166.95694$

b. Add A_3 and divide by 2 to get $A_5 = 38207.11714$

(So far we do not know how many more than two digits are correct.)

Stage 3.

a. Divide the original number by A_5 to get $A_6 = 38207.07492$

b. Add A_5 and divide by 2 to get $A_7 = 38207.09603$

(This is correct to at least 6, possibly 7 digits.)

Stage 4.

a. Divide the original number by A_7 to get $A_8 = 38207.09604$

b. Add A_7 and divide by 2 to get $A_9 = 38207.096035$

(Root is correct to 9, possibly 10 digits.)

Example 3

An odd number of decimal places and a decimal point give no trouble. Suppose the number is 14597.82187. Round it to 14600.00000, i.e., $(146)(10^2)$.

Stage 1.

a. A first approximation is clearly $A_1 = 120.0000$

b. Divide the original number by A_1 to get $A_2 = 121.64852$

c. Add A_1 and A_2 and divide by 2 to get $A_3 = 120.82426$

Stage 2.

a. Divide the original number by A_3 to get $A_4 = 120.81863$

b. Add A_3 and divide by 2 to get $A_5 = 120.821445$

Stage 3.

a. Divide the original number by A_5 to get $A_6 = 120.8214474$

b. Add A_5 and divide by 2 to get $A_7 = 120.8214462$

(This is correct to 8 or 9, possibly 10 digits.)

Editorial Note: It is interesting to see why this method converges to an accurate answer as rapidly as it does.

Let N^2 be any positive number whose square root, N, we seek to approximate by this "averaging" method.

Let $A_1 = N + x$ be our first approximation, i.e., the "guessed" value of N. (x may be positive, negative, or zero, but once built into our first approximation A_1, it remains fixed for the succeeding steps.)

Then the method gives a second approximation

$$A_2 = N^2/A_1$$

and a third approximation

$$A_3 = (A_1 + A_2)/2.$$

Substituting for A_1, A_2 and simplifying, we find

$$A_3 = N + \frac{x^2}{2N}\left[\frac{1}{1 + (x/N)}\right]$$

$$= N + \frac{x^2}{2N}\left[1 - \frac{x}{N} + \frac{x^2}{N^2} - \cdots\right]$$

from which we get

$$A_3 \sim N + x^2/2N.$$

Continuing the process, the fourth approximation is

$$A_4 = N^2/A_3$$

and the fifth approximation is then

$$A_5 = (A_3 + A_4)/2$$

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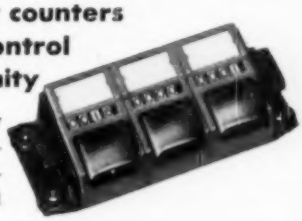

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Substituting for A_3, A_4 and simplifying gives

$$A_5 = N + \frac{x^2}{4(N+x)} - \frac{x^2}{4(N+x) + (2x^2/N)}$$

$$= N + \frac{x^2}{4(N+x)}\left[1 - \frac{1}{1 + \dfrac{x^2}{2N(N+x)}}\right]$$

$$= N + \frac{x^2}{4(N+x)}\left[\frac{x^2}{2N(N+x)} - \frac{x^4}{4N^2(N+x)^2} + \cdots\right]$$

whence

$$A_5 \sim N + \frac{x^4}{8N(N+x)^2}.$$

Continuing the method one step further gives

$$A_6 = N^2/A_5$$

$$A_7 = \frac{1}{2}(A_5 + A_6).$$

Again, substituting and simplifying yields

$$A_7 = N + \frac{x^4}{8(N+x)\,[2N(N+x) + x^2]} - \frac{x^4}{8(N+x)\,[2N(N+x) + 2x^2] + (2x^4/N)}$$

$$= N + \frac{x^4}{D} - \frac{x^4}{D}\left[\frac{1}{1 + (2x^4/ND)}\right]$$

$$= N + \frac{x^4}{D}\left[\frac{2x^4}{ND} - \frac{4x^8}{N^2D^2} + \cdots\right]$$

$$= N + \frac{2x^8}{ND^2} - \frac{4x^{12}}{N^2D^3} + \cdots$$

so

$$A^7 \sim N + \frac{2x^8}{ND^2}$$

$$= N + \frac{x^8}{32N(N+x)^2\,[2N(N+x) + x^2]^2}$$

The stopping points in this process are at A_3, A_5, A_7. Looking at these we see that

$$(A_3 - N) \leqq x^2/2N$$

$$(A_5 - N) \leqq \frac{x^4}{8N(N+x)^2}$$

$$(A_7 - N) \leqq \frac{x^8}{32N(N+x)^2\,[2N(N+x) + x^2]^2}$$

The analysis could be carried further, but the algebra required to do so becomes formidable. Even after only three stages, we see that the agreement between A_7 and N must be extremely good if x is small relative to N. On a calculating machine one can readily carry the process through as many stages as the machine will accommodate. Obviously, the smaller we can make x in the first approximation, $A_1 = N + x$, the faster will be the convergence to an accurate approximation for the desired square root, N.

For example, suppose that in A_1 the x is as large as 5 percent of N. Then $x = 0.05$ N, so we are led to

$$(A_3 - N) \leqq (125)\ (10^{-3}N)$$

$$(A_3 - N) \leqq (7)\ (10^{-7}N)$$

$$(A_7 - N) \leqq (25)\ (10^{-14}N)$$

Practically, of course, these relations are of little value because we don't know N, but they do give a specific insight into the rapidity of convergence even with as large as a 5 percent error in starting the process.

In practice, of course, one continues the process until the observed agreement between A_{2k-1} and A_{2k-2} is exact to the accuracy desired for the root. Thus, in Example 1, note the agreement between A_5 and A_4, and in Example 2, that between A_7 and A_6, or between A_9 and A_8. If the capacity of the machine is not sufficient to yield the agreement sought, then A_1 was chosen too far from N to give the desired convergence within the limits of the machine, so a new A_1 must be chosen closer to N and the process repeated by beginning with this better choice of A_1.

M. E. W.

RHYME, RHYTHM, AND REASONING

Statistical quality control and its specialized terms sometimes send engineers into the realm of rhyme and rhythm. The stanza-ed product below is the considered output of an engineer who recently completed a course in quality control and sampling in the Quality Assurance Department of the Bell Telephone Laboratories. The author, Mr. W. Kuhn, is a Member of Technical Staff of the Laboratories. Names quoted apply to instructors.

QUALETROL PROBATISTICAL

The laws of probability,
Require mentiligility
Out beyond the normal mind of mortal man;
And matters mathematical,
Erratic and statistical,
All have thoughts my vacant mind just cannot span.

A standard deviation,
Is some mystical relation,
Say between an average X and its prime;
Which proves that two lead nickels,
Or other worthless shekels,
Plus a ten cent silver piece are worth a dime.

When curves have shape symmetrical
It's highly probabilical
That the skewness factor k will tend toward zero;
But this useful bit of knowledge
Not often taught in college
Was unknown when Rome was run by Old King Nero.

To make a good example,
You must take an ample sample,
With a proper rat-i-o of n and N;
You should know your p's and q's,
Or I have for you some news,
Your equation won't be worth a wooden sen.

If you tend to subjects arty,
You'll prefer statistics charty,
With a zig-zag line to show the range of R's;
But when making calculation
There must be the stipulation
That your R is surely written with a bar.

We must catch each dereliction,
In our quality inspection,
All our products must be rid of nonconformance;
Let them carefully detect
Each and every small defect
Every error which may give a poor performance.

In too-long examinations
Mine were minus deviations
Which just shows my mind is surely in a mess;
If they take my d sub u
And divide the thing by two
Then I may alas just pass-I hope-I guess.

To me a sigma
Is still an enigma.

But here's to Dodge, M. Kruger and Miss Torrey
They *tried*—to their undying glory.

SUPERVISOR'S CIRCLE

PAUL A. ROBERT, *Editor*

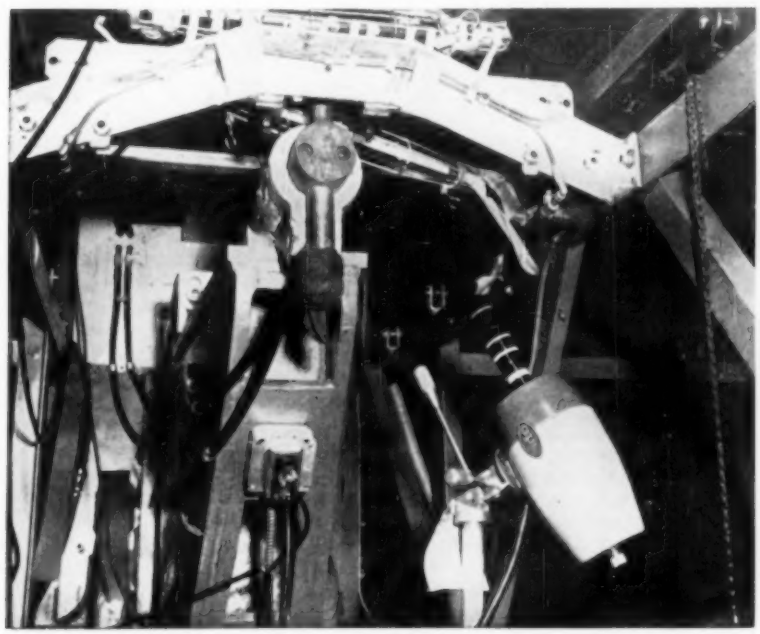
Gruen Watch Company, Time Hill, Cincinnati, 6, Ohio

TV System Assists Quality Control in Airframe Spotwelding

Closed-circuit television has replaced the human eye in watching structural spotwelding on the underside of large aluminum panels of the KC–135 jet tanker-transport skins.

At the Ryan Aeronautical Company, San Diego, California, a small TV camera staring untiringly—and with electronic accuracy and clarity—at the welds, transmits a magnified report via coaxial cable to a 17-inch monitor screen at the side of the welder. No longer must a human "bird watcher" be stationed beneath the welding platform to assure the highest quality; at a glance, the single operator now sees the condition of both top and bottom welds.

Because of the heat and pressure necessary to accomplish spotwelds, the copper alloy welding tips soon pickup aluminum from the "clad"—an outer layer of pure aluminum which covers the harder alloy core. Since clad is the protective coating which prevents corrosion of the metal, it is important in aircraft manufacture that this "pickup" be kept to a minimum and both welding electrodes cleaned when the deposit becomes noticeable. Through the use of television, the welder now can stop the moment the first sign of electrode pickup appears on the screen.

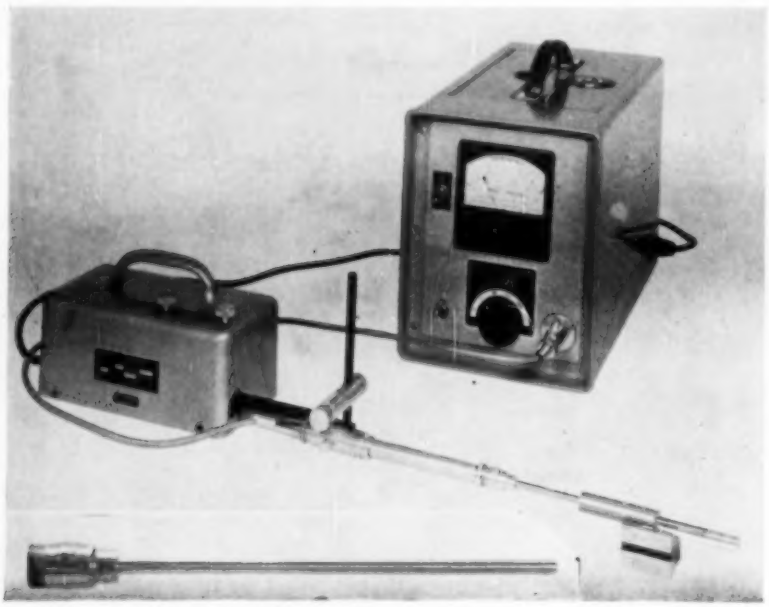


The TV camera, set up on an arc with simple bracketry, moves to coincide with the longitudinal and cross-wide motions of the panel. Remotely powered, it is operated by a flip switch and follows the line of welding in any direction. Two lenses provide either detailed close-ups of each spotweld or wide angle views which enable the operator to remove his work from the narrow clearance between the welding tips without bumping. A combination of fluorescent and incandescent floods are used to assure proper lighting without reflection from the aluminum panels or spotwelds.

What's New?

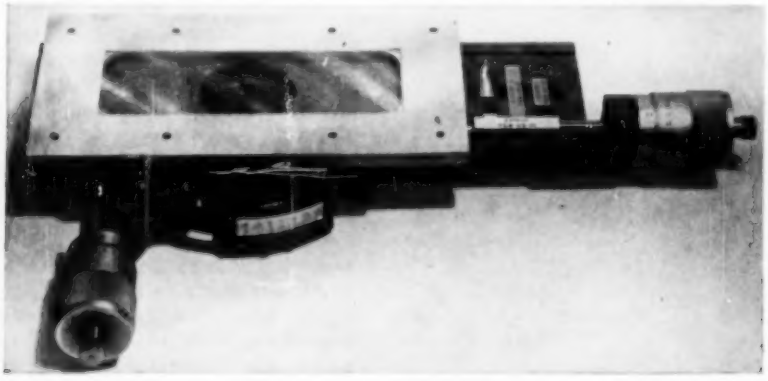
ROY A. WYLIE, *Editor*

When inquiring about "What's New?" items, please mention INDUSTRIAL QUALITY CONTROL



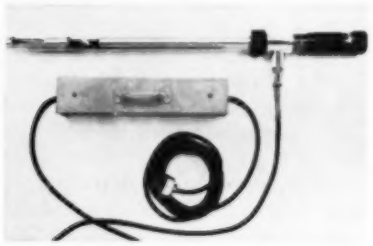
The Profilometer Type LC Tracer for measuring surface finish in ¼ inch diameter holes to a depth of 6 inches has been announced by the **Micrometrical Manufacturing Co.**, 345 South Main Street, Ann Arbor, Mich. The Type LC Tracer is also available in longer or shorter lengths depending upon the requirements of the job. Full details and specifications are given in bulletin LT 131 available on request from the manufacturer.

★ ★ ★



A 1 × 6 inch Measured Travel Coordinate Stage, useful for precise measurements and adjustments, is announced by **Stocker & Yale, Inc.**, Marblehead, Mass. The new stage, designed primarily for use with the company's lines of optical comparators, may also be used with microscopes or other means of optical observation. Accurate measured coordinate travel in the 1 × 6 inch range is provided by means of hardened and ground preloaded precision ball V-ways. Readings are made on a choice of micrometers of 0.0005 inch increments or 0.0001 inch increments. Two 2.000 inch and one 1.0000 inch size blocks are standard equipment and provision is made for storing the size blocks in the stage base when not in use. Helix adjustment with locking device is standard equipment and provides rotational adjustment of 15 degrees right and left of zero. The top surface of the stage is flat with a series of 8 tapped holes to aid in fixturing. Dovetail plates, designed to fasten to the stage and to accommodate standard fixtures now on the market, are also available further increasing the fixturing possibilities. Four tapped holes in the stage base provide mounting means.

★ ★ ★



A new borescope developed by **Lenox Instrument Co.**, 2010 Chancellor Street, Philadelphia 3, Pa., permits complete internal inspection of tanks, vessels, combustion chambers and other equipment by means of an adjustable mirror which can be controlled by a handwheel to permit scanning from retrospective through right angle to forward oblique. The larger field of view offered by this instrument makes it easier to detect flaws, pits, cracks or deterioration. The Lenox borescope gives a magnification of 10 power, a field of vision 9 inches in diameter at a distance of 24 inches, and has a viewing head with a 13/16 inch diameter 100 watt lamp for illumination. Modifications of this instrument to meet specific applications can be made.

★ ★ ★

The **Learcal Division of Lear, Inc.**, 3171 South Bundy, Santa Monica, Cal., has developed a new type of Gyro Drift Recorder capable of detecting, indicating and recording with extreme accuracy the minute increments of drift characteristic of modern high-precision gyros. It produces a paper chart which reflects only the drift and random disturbances. The machine ignores Scorsby motion, dither, and other cyclic motions while remaining highly sensitive to drift and random disturbances, and provides an accurate permanent record of the mean shaft position of any mechanical device that is subject to a gross symmetrical motion. The pen motion is deliberately limited to a rate of 2-degrees per minute, resulting in an

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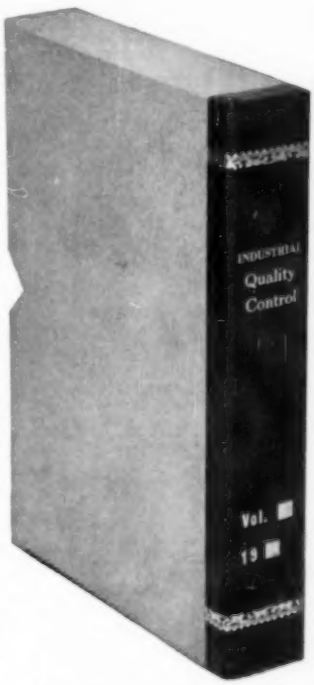

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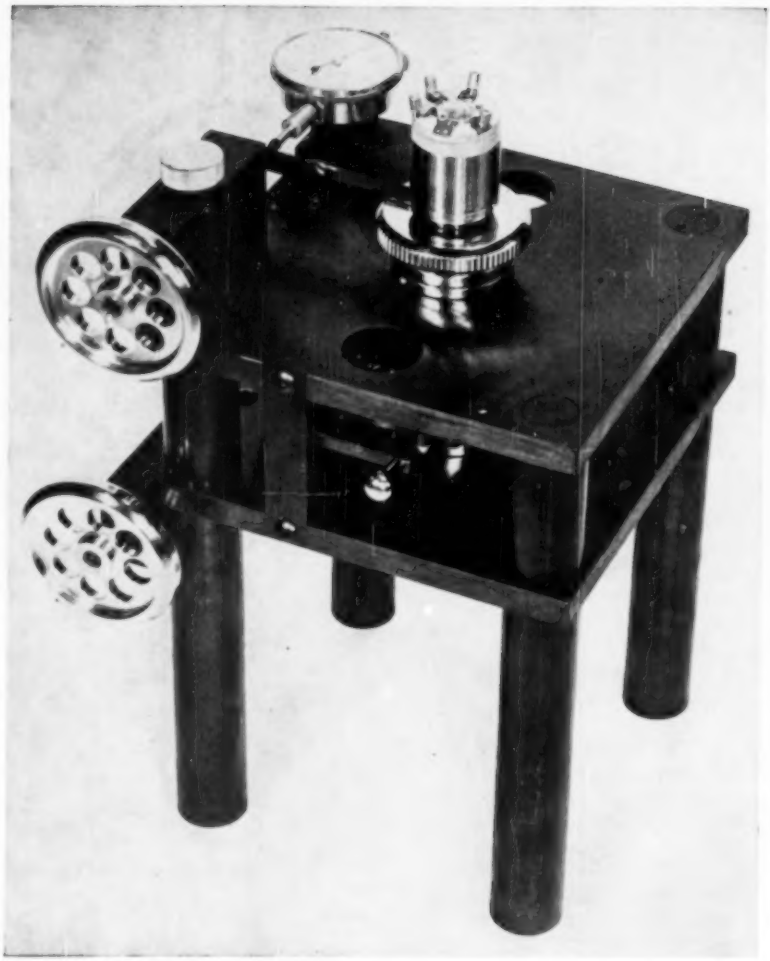
accurate plot of mean position, including extremely low velocity relative motion, while ignoring cyclic motional velocities of unlimited amplitude, occurring at rates as low as 1 cycle per minute. A 10-degree sector of shaft rotation is plotted across 2 inches of chart width, and the chart is pulled past the pen at 12 inches per hour. The paper is imprinted with heavy scoring at each degree, and lighter scoring appears at 1/5 degree intervals. Heavy scoring occurs at 1 minute intervals with 1/5 minute intervals more lightly indicated; 15 minute intervals are also noted.

★ ★ ★

A new divider head with wide adaptability for testing rotating instruments within extremely close limits has been announced by **Path Engineering and Machine Products** of Santa Monica, Calif. The unit was designed to test any device while mounted vertically and supported by its shaft . . . such as synchros, resolvers, potentiometers, gyro pick-offs and induction pots. Testing errors are non-accumulative and no error can be introduced by forces caused by shaft run-out. Dual index marking, clockwise and counter-clockwise, permits testing instruments which rotate positively in either direction. The indicator on a mounting arm measures in thousandths, which is directly converted to minutes. Angular errors are displayed directly and rotation from 0 to 360 degrees can be checked by making only 10 settings. The new divider head is a complete testing unit, measuring 8 inches square and 8 inches high over-all, but can be adjusted higher for testing larger units. Units may be mounted top and bottom, "back to back", for simultaneous testing with individual adjustment of standard and unknown.



★ ★ ★

The **Alpha Molykote Corp.**, 65 Harvard Avenue, Stamford, Conn., has described in Bulletin 106 the Alpha Lubricant - Friction - Wear Testing Machine. The machine is a compact unit for testing dry and liquid lubricants, friction and wear characteristics of various materials. In operation, a stationary rectangular

Statistician

Challenging salaried position for an industrial statistician in our newly reorganized quality control division. Prefer chemical education and experience in chemical manufacturing. Must have thorough working knowledge of advanced statistical methods to be able to work as statistical consultant to chemists in product research division. Statistician will be fully responsible for recommending experimental designs to chemists and engineers and to aid in the interpretation of data. Statistician will also set up sampling plans, determine probabilities and risks, design control charts and management reports. Permanent location in Chicago, Illinois with some travelling to manufacturing plants. Liberal company benefits. Reply should give details of work experience, education, and salary history.

Simoniz Company

2100 Indiana Avenue
Chicago 16, Illinois

Attention: Mr. Vaughn Hardy,
Personnel Manager

CHEMICAL DIVISION

W. J. Chelgren, while still acting as General Chairman of the First Annual Technical Conference to be held in Philadelphia October 18-19, announced the following committee appointments.

Treasurer	Thomas P. Callan, Jr.
Arrangements	Richard N. Selvig
Program	Hillman C. Harris
Publicity	H. Mack Truax
Registration	Thomas J. Moran
Transactions	Kenneth H. Horowitz

Following W. J. Chelgren's transfer out of the Philadelphia area, Hillman C. Harris assumed the duties of General Chairman.

One of the features of the conference will be a session on Bulk Sampling co-sponsored by Committee E-11 of the ASTM. Ben H. Lloyd of Leetham, Simpson, & Lloyd, Ltd., Montreal, is representing ASTM in planning the session.

test block is pressed with a predetermined load (maximum 630 lbs.) against a rotating Timken ring. Bearing pressures in the line contact area between the rectangular specimen and the rotating ring may range up to 110,000 PSI. Resulting friction is indicated throughout the test by a dial indicator. A counter records the number of revolutions of the test specimen. One criterion in the test is where friction reaches a pre-selected maximum. For this purpose a control pointer on the friction indicator can be set for any pre-selected value of friction and the machine will automatically shut off upon reaching it. In a substitute method, a thermocouple is imbedded in the specimen and a temperature recorder controller (not standard equipment) terminates the test when the temperature of the test block reaches a previously set value.

★ ★ ★

A new borescope developed by **Lenox Instrument Co.**, 2010 Chancellor Street, Philadelphia 3, Pa., permits complete internal inspection of tanks, vessels, combustion chambers and other equipment by means of an adjustable mirror which can be controlled by a handwheel to permit scanning from retrospective through right angle to forward oblique. The larger field of view offered by this instrument makes it easier to detect flaws, pits, cracks or deterioration. The Lenox borescope gives a magnification of 10 power, a field of vision 9 inches in diameter at a

Correction Note

We are indebted to Dr. Aurelio Molaroni of Milano, Italy for a note calling attention to two misprints in the Satterthwaite article published in the May 1957 issue.

The first error appears in the first of the two formulas in the second paragraph of the section "A Suggestion" on p. 58. This formula *should* read

$$\chi_\alpha{}^2(m) = mF_\alpha(m, \infty)$$

rather than

$$\chi_\alpha{}^2(m) = m/F_\alpha(m, \infty)$$

as it appears on p. 58. The correct formula has been used in the numerical Example 1.

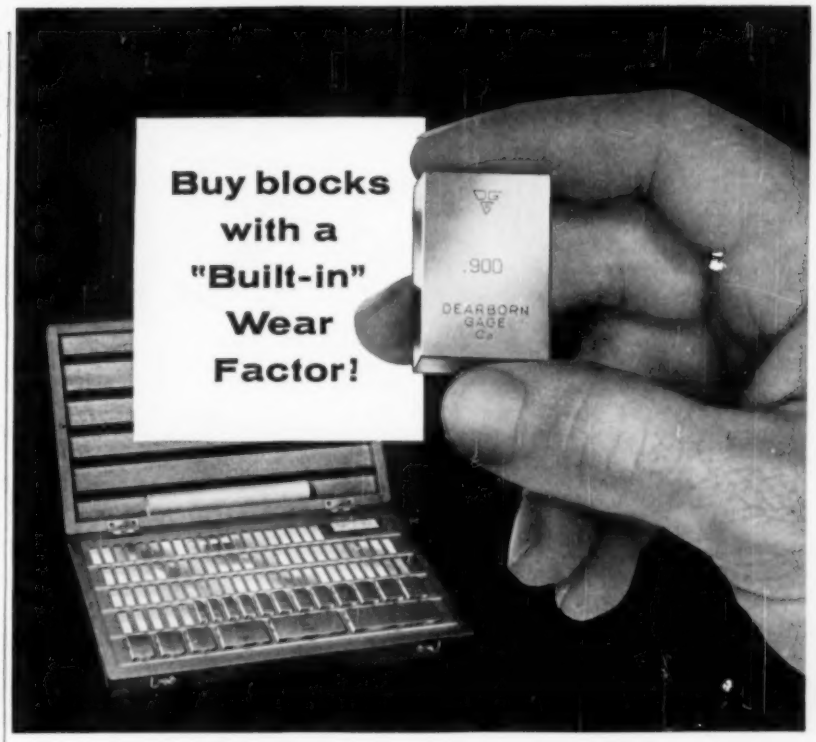
The second error is in the last formula in the third line above the end of this same section. The correct formula *should* read

$$\chi_\alpha{}^2(m) = m/F_{1-\alpha}(\infty, m)$$

rather than

$$\chi_\alpha{}^2(m) = mF_\alpha(m, \infty)$$

as it appears on p. 58. Again, the correct formula has been used in the numerical Example 2.



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Here at last are gage blocks with a positive "built-in" wear factor! The only blocks ever produced and priced as standard with dimensional accuracy unconditionally guaranteed to be within specified millionths on the "plus" side of nominal block size and minus "zero" . . . absolutely nothing . . . undersize!

This complete elimination of the conventional minus tolerance gives you, the gage block user, three new and exclusive benefits. First, it provides positive assurance against receiving new blocks that are actually "worn" undersize during manufacture before they are ever used. Second, it gives you finer, more practical accuracy . . . with the sure knowledge that every Ellstrom block you buy will start wearing *toward* its nominal size rather than away from it. And third, it gives you a guaranteed minimum wear factor equivalent in millionths to the full minus tolerance specified as standard for all other makes of blocks!

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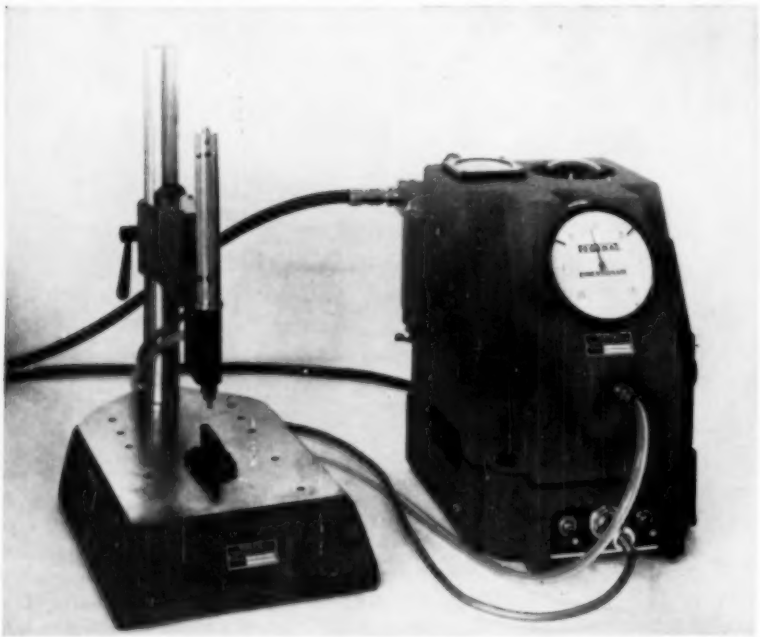
Ellstrom—your best buy in gage blocks for shop and tool room use, inspection and laboratory applications. Available in 28 standard sets ranging from 8 to 92 blocks in both square and rectangular styles with or without basic gage block accessories.

distance of 24 inches, and has a viewing head with a 13/16 inch diameter 100 watt lamp for illumination. Modifications of this instrument to meet specific applications can be made.

★ ★ ★



Extremely delicate parts such as light springs, bellows, diaphragms, vacuum tube grids and the like can now be measured without fear of distorting them by means of a "pressureless" comparator manufactured by **Federal Products Corp.** of Providence, R. I. This Air-Electronic Gage exerts practically no pressure on the workpiece—testing shows that pressure amounts to 0.005 grams or approximately 1/10,000 of an ounce. The extremely low gaging pressure is obtained through an arrangement in which the sensitive gaging contact is raised and lowered by a special type of wire. The wire has rapid response to heat and is made to fluctuate in length by being alternately heated and cooled. To begin the gaging cycle, a workpiece is placed in position and the gage switch turned to GAGE. This applies heat to the wire. As the wire heats, it lengthens and the sensitive gaging contact moves toward the workpiece. As soon as the contact touches the work it establishes a circuit which removes the voltage across the wire, allowing it to cool so that it contracts. This raises the gaging contact from the workpiece, breaking the arresting circuit so that the wire begins heating again. Once more the gaging member is lowered until contact is established with the work. This action takes place so rapidly that it gives the impression that the contact is hovering over the work. The gaging mechanism consists of a gage head connected by a frictionless motion transfer unit to the sensitive contact and by a plastic hose to a Dimensionair Air Gage. The movement of the sensitive contact causes a target face in the gage head to move against an air jet so that the movement can be seen on the Dimensionair Dial.

★ ★ ★

The Electronic and Instrumentation Division of **Baldwin-Lima-Hamilton Corp.**, 42 Fourth Street, Waltham, Mass. has announced that printed circuits and transistors have been used to give the new Baldwin Type N Indicator improved accuracy, life, and range. Advantages obtained by this construction are: (1) There is no calibration error when the instrument is used for direct readings with a full external bridge instead of a pair of strain gages; (2) When the indicator is used as a preamplifier with a standard cathode ray oscilloscope, visual indications of dynamic strain can be obtained with a better response and in a broader range than could be obtained with the previous model. Frequencies up to 300 cycles per second at amplitudes as high as 3500 micro-inches per inch can be observed without appreciable distortion; (3) Except for the batteries, there are no expendable components; (4) The batteries last five times as long as they did in previous indicators, and they

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Work in America's largest and finest aircraft manufacturing facility on production of the Supersonic B-58 and nearly half-a-hundred other Air Force contracts now on hand. Enjoy pleasant living in mild year-'round climate, salary and employee benefits that are tops in the industry!

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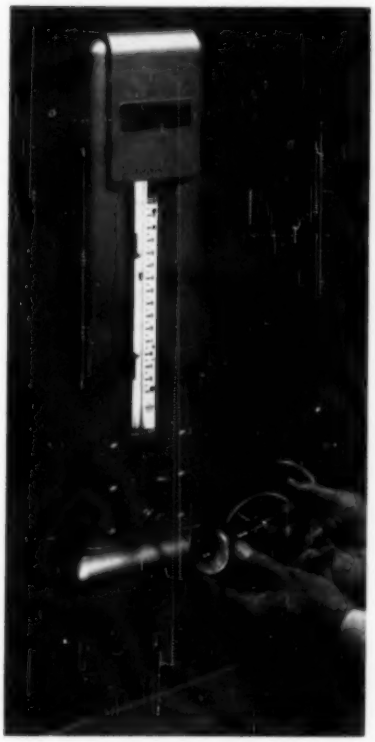
cost only a third as much; (5) The Type N weighs only a third as much (nine pounds) as the Type M, is in a smaller case (10 inches high by 9 inches wide by 6¼ inches deep) and requires no warm-up period. Additional data on the Type N strain indicator can be obtained from the manufacturer.

★ ★ ★



To facilitate easier, faster reading and worker eye-comfort in plant areas where massive machinery shuts off natural or other overhead lights, the Sheffield Corporation is providing a new series of illuminated models of its Precisionaire air gages. Lights have been applied to five models of Sheffield's standard 1-column to 5-column Precisionaires and also to a new model Micronaire, an air gage standard in testing of cotton fiber fineness. Further information on the illuminated models of its Precisionaire air gages may be obtained from the **Sheffield Corp.**, Dayton 1, Ohio.

★ ★ ★

Macbeth Instrument Corp., Post Office Box 950, Newburgh, N. Y. has announced the new Macbeth-Ansco Electronic Densitometer, Model 12A. This instrument features direct reading in linear density scale, 0 to 4.0 in color and black and white; all new fundamental optical system; elec-

tronic zeroing; separate zero adjustments for each color filter; separate calibration circuit for reflectance density measurements and transmission density measurements; illuminated stage for sample positioning; filter holding mechanism for easy installation of additional filters, including interference filters. The instrument also incorporates a dynode feeding photo multiplier tube circuit for excellent stability and sensitivity. Price is $985.00 for the basic unit and the reflection head attachment is $195.00 additional.

★ ★ ★

A new hydraulic Tensile Tester to determine bolt tension and calibrate impact wrenches, has been announced by **Skidmore-Wilhelm Co.**, 442 S. Green Rd., Cleveland, Ohio. This ruggedly built, portable shop tool should provide receiving inspection with an immediate answer as to whether or not incoming bolts and fasteners have the tensile strength required by specification. The unit is self-contained, and is equipped with a meter which reads directly in pounds of tension. Three models have gages for bolts from #10 × ¾ inches long to ½ × 1¾ inches long; from ⅝ × 2¾ inches long to 1 × 2¾ inches long; and

Gaertner Toolmakers' Microscope used to measure typical piece part. Co-ordinate range 4" x 2".

Precise measurement to 0.0001" and 1 min. of arc

Gaertner Toolmakers' Microscope

Here is a reliable, easy-to-use microscope for precise measurement of piece parts, tools, dies, thread gages, templates, jigs, fixtures, etc. Ideally suited for making a wide variety of precision measurements and is especially valuable in reducing rejects in production work.

With the Gaertner Toolmakers' Microscope you make direct, non-destructive measurements — no contact, no distortion, images are sharp and clear. It is a basic measuring instrument for inspection depts., gage labs, tool and die and model shops, industrial and research labs.

The Gaertner Toolmakers' Microscope has been proven in use by U. S. Government Gage Laboratories, and by prime contractors and their subcontractors. With all parties using the same measuring instrument, inspection procedures are co-ordinated and disagreements and rejects minimized.

Features that help you get
HIGH SETTING AND REPEATING ACCURACY

- Low, compact built-in rotary stage reads to 1 minute of arc throughout 360° range.
- Minimum overhang of stages.
- Full 2" precision-lapped lead screws with correction device.
- Straightforward, direct, uncomplicated optical system.

Features that assure you of
EASY, CONVENIENT OPERATION

- Independently rotatable cross hairs in protractor ocular speed up measurements, simplify measuring procedure.
- Convenient location of ocular eyepieces for ease of reading.
- Built-in transformer and plugs for all illuminators.

Modifications and accessories to
MEET YOUR EXACT REQUIREMENTS

- Thread and radius templates, camera and spotting attachments, fine motion focus, variable magnification available.
- If you have a special measuring problem, our staff of representatives will be happy to consult with you. The service and engineering facilities of the manufacturer are always immediately available to help you.

Write for Bulletin 147-56

Designed and manufactured by

The Gaertner Scientific Corporation

1248 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

Quality Control Engineer

Challenging salaried position for experienced quality control engineer to assist in setting up program for our quality control division. Must have degree in chemical engineering or chemistry with at least 5 years experience or training in statistical quality control in chemical industry. Some advanced statistical quality control work will be helpful. Will be responsible to audit plant quality control procedures, to analyze plant quality control records, to suggest corrective action possibilities, to conduct in-plant training program in elementary quality control, and to evaluate plant inspection effectiveness. Permanent location in Chicago, Illinois with frequent travelling to manufacturing plants. Liberal company benefits. Reply should give details of work experience, education, and salary history.

Simoniz Company

2100 Indiana Avenue
Chicago 16, Illinois

Attention: Mr. Vaughn Hardy,
Personnel Manager

from ⅝ × 2¾ inches to 1¼ × 4 inches long. Accuracy is certified over full scale reading to 2 percent. The Tensile Tester uses a hydraulic principle of operation, enabling the operator to make quick checks without special training. A screw is tightened in the tester with any wrench, and through hydraulic pressure this tension is transferred to the meter which reads directly in tension applied. The instrument may also be used in making proper calibration settings on impact wrenches. Tests are made by tightening a bolt in the instrument with an impact wrench and checking the impact wrench setting against the dial to determine whether or not the right tension has been achieved.

★ ★ ★

A completely self-contained, portable unit is now available for the proper application of dry Magnaflux powder, from the **Magnaflux Corp.**, 7300 West Lawrence Avenue, Chicago 31, Ill. The No. 58600 Powder Blower operates directly from any air line and requires only 20 p.s.i. A simple adjustment controls the density of the cloud of powder, and two push buttons permit selection of either powder or clean air. By holding the gun level and at a distance from the area being tested, the particles gently flood the entire area, showing clear indications when cracks are present. The blower is compact and weighs only 2¼ pounds empty. It is simple to operate and has advantages over the shaker-type powder bulbs in that it is faster, covers a wider area, and distributes the magnetic particles evenly. The price is $95.00 and the unit is available from stock.

★ ★ ★

NEW LITERATURE

A new booklet on "Gage Laboratory Instruments and Services" just published by the Sheffield Corp., Dayton 1, Ohio, features instructions, specifications and a layout guide explaining how individual manufacturing plants may set up their own gage laboratories to meet requirements for closer and more convenient control of parts measurement standards.

Techalloy Company, Inc., Rahns, Pa., have made available procedures for a one-minute identification test for Monel, Nickel and Stainless Steel type 302, 304, 316 and 317. Called the Moly Test, it uses an electrographic method to determine the metal. Moly Test does not require elaborate equipment, is easily set-up and gives positive and accurate results in one minute. Equipment needed is a 6 volt dry cell battery, aluminum strip, photographic blotting paper and spot reaction paper. Three solutions are used and their formulas given. Results which determine the metal tested are explained. Complete instructions for Moly Test are available without cost from Techalloy Company, Inc.

Pratt & Whitney Company, Inc., West Hartford, Conn., has published a new, handy Select-Aire Chart complete with full listing of all popular gage plug types, sizes and specifications as a time-saver in selecting and ordering the Air-O-Limit Plugs. The company is now able to deliver accurate Air-O-Lim-

QUALITY CONTROL METHODS AND MANAGEMENT

The result of the symposium held last fall at Drexel Institute of Technology and sponsored by the Philadelphia section is nine papers which comprise the "symposium transactions."

These papers present some of the quality control methods that are tools for management and also present some management views on quality control. Here are the subjects covered.

Statistical Quality Control in a Job shop
A Dynamic Quality Training Program
A Discussion of Some Simple Experimental Designs
Some Aspects of the Regression Technique
Decision Making-Facts, Fantasy and Fundamentals
Quality Improvement Campaign
Management Takes a Look at Quality Control (two papers)
Quality Control Helps Solve Inspection Problems

Copies of the transactions are available at $1.00 per copy.

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Please send me.....copies of "Quality Control Methods and Management" at $1.00 per copy. Enclosed.....

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it Gage Plugs in a wide range of popular sizes in just two weeks from the time an order is received at the Pratt & Whitney plant in West Hartford. Other types and sizes can be delivered in three weeks or less. A wide variety of plug blanks is carried in stock at all times and upon receipt of an order, it is necessary only to grind to exact specifications, harden and plate the plugs before shipping.

A new bulletin recently issued by the Testing Machines Division of Gries Industries, Inc., New Rochelle 6, N. Y., covers methods and machines for rapid yet "standard" Brinell Hardness Tests in routine production. The bulletin also states that it is now possible to see automatically the diameters of the ball impressions (as required by the "standard" specifications of the Brinell method) on a motorized machine for rapid production Brinell testing. Heretofore motorized machines have only shown the depth of the ball impressions.

Newage Industries, Inc., 222 York Road, Jenkintown, Pa., have published a four page folder illustrating and describing the many features of their easily operated, accurate, portable, 30-ounce hardness testing instrument which can be used in any position to test the hardness of any size, shape or type metal.

In gaging screw diameters, it makes a big difference whether you twist the screw into the gage or the gage onto the screw. This fact is clearly illustrated in a new thread gaging booklet by Standard Pressed Steel Co., Jenkintown, Pa. The booklet points out that failure to observe these and other basic gaging techniques is causing industry to accept misfit fasteners with resulting troubles in the assembled product or on the production line. Copies of the booklet are available on request.

Bulletin 1547A published by Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif. describes the Consolidated Electromanometer, a precision pressure measuring device for laboratory, field, or automatic process control. The device provides rapid high-accuracy pressure measurements which are extremely difficult to obtain with mercury manometers.

Isotope Products, 1711 Elmwood Avenue, Buffalo 7, N. Y. announces the publication of a new bulletin, "Basis Weight and Moisture Control Systems for the Paper Industry." This bulletin indicates the advantages to the paper maker of various engineered machine control systems. The basic control systems using the Betameter for Basis Weight and Aquatel for moisture control are outlined in the bulletin.

The Type 1810 Pulse Calibrator, a new instrument designed for accurately measuring current and voltage pulse amplitudes, pulse durations and rise time, is now fully described in a technical brochure just published by the Electronic Instruments Division of the Burroughs Corp., 1209 Vine Street, Philadelphia 7, Pa. The four page brochure shows how the Calibrator operates, illustrating and explaining actual waveforms obtained from different applications of the unit. Complete theory of operation of the two sections of the Calibrator, the Chopper Section and the Calibrator Section, along with the specifications, is included.

Correction in Board of Directors

Warren R. Purcell
Industrial Consultant
Rath & Strong, Inc.
Boston, Mass.

Apologies are in order. In the July issue, page 25, we displayed the 1957-58 Board of Directors. But alas, we goofed and a clerical error resulted in Warren R. Purcell not appearing as a member of the Board. Instead we showed R. Shaw Goldthwait, who is really District #1 Representative, in Mr. Purcell's place. We are very sorry for this gross error and hope that this correction notice will help to rectify the situation.

DO YOU HAVE A QUALITY CONTROL PRESENTATION PROBLEM?

QUALITY CONTROL AIDS ARE THE ANSWER

Make your presentation more forceful and understandable by the use of these aids.

QUINCUNX
... This device permits your audience to visualize the creation of a normal distribution pattern as well as the results of variables sampling. All beads are self-contained; nothing to drop out. Done in attractive mahagony complete with zipper carrying case.

ATTRIBUTE SAMPLING DEMONSTRATOR
... Complete unit consists of transparent plastic container, opaque colored beads, and wood paddles permitting easy identification of beads at a distance.

SIMULTATORS
... To demonstrate control chart plotting and shift of distribution pattern.

Lightning Calculator Co.
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St. Petersburg Beach 6, Fla.

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These advertisers provide educational information on their products, expanding the services of your journal, *Industrial Quality Control.*

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When writing or talking to advertisers to inquire about their products, always remember to say you saw their ad in *Industrial Quality Control.*

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section briefs

Calendar

The **BOSTON** section will meet Sept. 18, 6:30 pm, at the MIT Faculty Club to hear guest speaker Dorian Shainin.

The **COLUMBUS** section will meet Sept. 18, 8:00 pm, at the Kimble Glass Company to hear Dr. Julian H. Toulouse present "Finding the facts before setting specifications."

The **CORNING-ELMIRA** section will meet Sept. 10, 8:00 pm, at Corning to hear Prof. Mason E. Wescott present "The cookbook ain't enough."

The **MICHIGAN** section will sponsor the Twelfth Annual Michigan Forum to be held Sept. 7 at Angell Hall on the University of Michigan Campus, Ann Arbor, Mich.

The **MID-HUDSON** section will meet Sept. 3, 8:00 pm, at the Anchor Inn, Poughkeepsie, N. Y.

The **ROCHESTER** section will meet Sept. 17, 6:15 pm, at the Chamber of Commerce.

The **ST. LOUIS** section will sponsor a one-day clinic on Thursday, Oct. 3.

The **SOUTH TEXAS** section will meet Sept. 11, 5:00 pm, at the Continental Can Co. A plant trip is planned and will be followed by a dinner meeting with the location of the dinner meeting to be announced.

The **TORONTO** section will meet Wednesday, Sept. 11, 7:30 pm, at the University of Toronto to hear J. C. Knapp present "Planning quality control."

BALTIMORE . . . Following a very successful annual dinner meeting featuring Lt. Col. Harry R. Gilbert of the Army Chemical Corps, attended by 100 members and guests, the new officers are planning an interesting, possibly exciting, 1957-58 season. The entire year's program should be ready for publication by early fall. The new officers are: W. A. MacCrehan, Bendix Aviation, chairman; E. M. Glocker, Davison Chemical Co., vice chairman; F. J. Cullen, National Plastics Corp., secretary; R. G. Hutter, Proctor Electric Co., treasurer.

BINGHAMTON . . . At its first meeting of the year, the section directed its attention primarily to the planning of the year's activities.

Of particular interest was the discussion centered around plans which Roberson Memorial has to coordinate the efforts of their educational group in the Technical Engineering Council for Youths—through parent and student participation—with the section.

Officers elected for the year are: chairman—Charles H. Rubin; vice chairman—Joe Jirauch; secretary—Don Moses; treasurer—Mike Drabo.

BOSTON . . . The fourth annual 3-day seminar on QC for management, sponsored by the section, was held June 17-19. Those attending exhibited the same high degree of enthusiasm demonstrated at previous seminars.

Pre-meeting sessions on selected QC subjects will be continued starting with the opening fall meeting Sept. 18.

BUZZARDS BAY . . . Kenneth E. Bennett presided at an executive board meeting held June 18 at the Continental Screw Company. Geraldine Habicht was appointed treasurer and Mary Lindenberg was appointed Saddoris Award chairman. The board voted to sponsor a basic quality control course in September and an advanced course in January.

COLUMBUS . . . The annual meeting of the officers and committee chairmen was held at the Colony Restaurant, June 12.

Dr. Julian H. Toulouse, the speaker at our Sept. 18 meeting, is chief engineer of the quality and specifications department of Owens-Illinois Glass Co. Dr. Toulouse served as a vice president of the Society for several years.

CORNING-ELMIRA . . . More than fifty members and guests spent a fine evening under the stars enjoying sports, dancing, and delectable food at our June picnic.

The section is eagerly awaiting the September appearance of Prof. Mason E. Wescott, the newest Shewhart Award winner.

GEORGIA . . . The section mail ballot for the election of new officers resulted in the selection of the following: chairman—James K. Kinkead, Dundee Mills, Inc., Griffin; vice chairman—W. Vernon Hassett, Martha Mills, Thomaston; secretary—Glenn C. Strickland, Naval Ordnance Plant, Macon; treasurer—L. W. (Bud) Miller, International Latex Corp., Newnan.

HAMILTON . . . On June 13 the old and new executives were guests of 1956 chairman Herb E. Markle, Leland Electric Canada, Ltd., at a dinner meeting held at the "Cutten Club," Guelph. Under new chairman Al Mitchell, Stelco, the committee chairmen discussed plans for an interesting program for the 1957-58 season.

HUNTSVILLE . . . The June 27 meeting was held at Decatur, Ala. William Spink, Chemstrand Corp., presented a paper on "Quality control in the synthetic fiber industry." Dr. Ellis R. Ott attended the session and outlined the Society's plans and efforts to provide service to the local sections.

MEMPHIS . . . The June 21 meeting was held at the Memphis plant of The Firestone Tire and Rubber Co. William W. Heiskell, quality control manager, gave a brief outline of quality control organization at the plant and presented two films about rubber production and tire manufacturing. Officers for 1957-58 were installed.

MICHIGAN . . . The 12th annual Michigan forum will be held Sept. 7 at Angell Hall on the University of Michigan campus, Ann Arbor.

This year's forum will consist of 12 separate technical programs designed to cover, on a clinical basis, the every-day quality problems encountered in the basic areas of purchasing, engineering, process control, and quality control administration.

The speakers who will present timely and challenging topics of great importance to quality control people are: Colonel John H. Ford, chief of inspection division, Detroit Ordnance District; J. Y. McClure, quality control manager of Convair, Fort Worth; J. N. Berrettoni, Berrettoni and Associates; Prof. C. C. Craig, University of Michigan; Prof. W. D. Baten, Michigan State University; D. A. Cue, assistant to the director of quality control, A. O. Smith Corp.

By providing instruction and orientation on quality control concepts and techniques, and by dedicating itself to the resolution of common quality problems in the functional areas of engineering, purchasing, and quality control administration, this year's forum promises to contribute substantially to the efficiency of Michigan industry and to advance the QC field.

MID-HUDSON . . . The executive committee met June 18 to discuss the speaker's list and to outline the 1957-58 program which begins on Sept. 3 at 8 pm at the Anchor Inn, Poughkeepsie.

The operating committee chairmen for 1957-58 are: arrangements—William Benesban and Paul Bassett; membership—Carl Wetzel; education and relations—William Bobalke; publicity and Saddoris Award—Harold Loper; speakers—Frank Sindelar.

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MILWAUKEE . . . On June 3 the executive committee and other committee chairmen met to formulate the program for the coming year, the highlight of which will be the visit and lecture by Sir Ronald Fisher, world famous statistician.

A motion was made and carried to authorize the transfer of $500 to the Society for the primary purpose of underwriting the cost of a membership brochure.

MINNESOTA . . . The section will open its annual program with a social meeting at Le Seuer where, as guests of the Green Giant Co., the section will have a dinner meeting at the Le Seuer Country Club.

PHILADELPHIA . . . The section, together with Drexel Institute of Technology, will hold their second annual symposium on "Quality methods and management" on Sept. 20. Outstanding speakers include Frank Caplan, Jr. from Westinghouse, Clifford Ryerson from RCA, Horace Machado from Hunter Spring Co., Stanley Zwerling from GE, Henry J. Jacobson from P. R. Mallory, and three other speakers. A luncheon meeting is planned, and the meeting will coincide with the regular monthly dinner meeting of the section. Further details may be obtained from George Nimick, Box 7409, Philadelphia 1, Pa.

ROCHESTER . . . Several years ago the section sponsored a library project in collaboration with Rundel Library. Over 100 QC books and publications are now available, over half of which were purchased with funds supplied by RSQC as a service to area industry and the community.

T. J. Soebbing, general membership chairman, is furnishing a complete list of publications at Rundel to the section membership.

ST. LOUIS . . . The section is planning a one-day clinic on Oct. 3. This clinic is to include a plant tour of the Ammunition Division of Olin Mathieson Chemical Corp. in the morning and three technical work shop sessions in the afternoon. The technical sessions will be conducted simultaneously and consist of a wide variety of new techniques which will permit the registrant to select the subject of his choice. This meeting is planned to emphasize "Quality control at work." A large turn-out is expected at this meeting.

SAN ANTONIO . . . The officers for 1957-58 are: chairman—John E. Goodwin, San Antonio Air Material Area (SAAMA); vice chairman—E. S. Garrett, Freidrich Air Conditioner, Inc.; secretary—R. W. Worrick, SAAMA; treasurer—J. F. Simon, SAAMA.

The section, now 31 active members with 11 "possibles," is planning to make an all-out effort to reach a total membership of 60 by the 1st of September. To stem this drive, all committee chairmen are eagerly pressing for success by making arrangements for "topnotch" speakers and programs within the coming months, which will stimulate greater interest in this area.

SAN FRANCISCO BAY AREA . . . The newly elected officers assumed office July 1 and presided at the July 8 meeting. Walter L. Hurd, Jr. of National Seal Division, Redwood City, is the new chairman; Allen Chop of Sylvania Electric Products, Mountain View, is vice chairman; Dr. Luis de Alcuaz, Consultant, is secretary; and Lyle D. Connell of Westinghouse Electric, Sunnyvale, is treasurer.

Allan Hull of United Air Lines, last year's chairman, gave a report on the past year's activities.

Sixty-seven members and guests attended this dinner meeting.

SOUTH TEXAS . . . The old and new executive committees of the section had a successful meeting on June 26. The new committee found the affairs of the section in excellent shape, as evidenced by our position in seventh place in the Saddoris Award competition.

TORONTO . . . On June 5 the section concluded its season with a ladies night at Malton Airport, near Toronto. A tour of the passenger handling, weather forecasting, and flight control facilities was made through the courtesy of our hosts, Trans-Canada Airlines, Ltd.

At the final meeting of the 1956-57 executive, retiring chairman J. D. Gardiner, Photo Engravers and Electrotypers, Ltd., thanked the committee members for their efforts during the past year and welcomed the new chairman, M. J. O'Callaghan, British American Oil Co. Ltd.

UNIV. OF WESTERN ONTARIO . . . The first executive meeting was held in Woodstock June 11. It was noted that the section had moved from 45th to 15th place in the Saddoris Award ratings. Eight meetings were scheduled for the coming season, plus four plant tours and two short training courses, one in London and one in Kitchener.

• • • SIGNIFICANT DIFFERENCES

. . . Buffalo—Richard S. Bingham, Jr. was promoted to the position of Supervising Engineer, Quality Control Branch, Research and Development Division, The Carborundum Co.

. . . Boston—O. H. Somers, recently with Winchester Division of Olin Mathieson Chemical Corp., has joined the Raytheon Mfg. Co. as quality manager of the semi-conductor division.

. . . Corning-Elmira—Frank "Gene" Butler has been appointed supervisor of quality control for the apparatus plant of the Corning Glass Works. Mr. Butler served the section as Saddoris Award chairman during the victorious 1956-57 campaign.

. . . Milwaukee—George Crayeraft, formerly with the John Oster Co., has accepted the position of chief inspector, Dynex Inc., Division of Blackhawk Mfg. Co., Pewaukee, Wis. He has also accepted the chairmanship of the 5th Milwaukee Clinic to be held in 1958.

. . . Toronto—Harold W. Kempling, our popular program chairman of the past season and recently elected secretary for 1957-58, suffered a very severe accident when he was struck by a motor vehicle and sustained multiple injuries. Mr. Kempling, who is in the Toronto General Hospital, is progressing favorably and the members of the section wish him a speedy recovery.

clinics, conferences, and forums

AUGUST

. . . **28-30**—National Gas Chromatography Conference, sponsored by ISA, Michigan State University, East Lansing, Mich., write H. S. Kindler, Director of Technical Programs, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa.

SEPTEMBER

. . . **4-11**—Advance Conference Series, Rutgers University, New Brunswick, N. J., write to Ellis R. Ott, University College, Rutgers University, New Brunswick, N. J.

. . . **5-6**—"QC and the Consumer," 2-day conference, Rutgers University, New Brunswick, N. J., write to Ellis R. Ott, University College, Rutgers University, New Brunswick, N. J.

. . . **8-13**—Second Annual Investment Castings Course, Massachusetts Institute of Technology, sponsored by the Investment Casting Institute, Chicago.

. . . **9-10**—4th Annual Western Regional QC Conference, San Francisco, Calif., write Allan M. Hull, United Air Lines, San Francisco Airport, San Francisco, Calif.

. . . **9-13**—12th Annual Instrument-Automation Conference and Exhibit, sponsored by ISA, Cleveland Auditorium, Cleveland, Ohio.

. . . **9-13**—Supervisory Development Course 1, given in three one-week units (Sept. 16-20, Oct. 21-25), Savoy-Plaza Hotel, New York, sponsored by AMA, contact Course Registrar, American Management Association, Inc., 1515 Broadway, New York 36, N. Y.

. . . **17**—Non-credit Course in Quality Control by Statistical Methods, Starts Tuesday, Sept. 17, 7:30-9:30 pm, and runs for ten consecutive weeks, Michigan State College, East Lansing, Mich., contact Dr. W. D. Baten, Michigan State College, East Lansing, Mich.

. . . **17-18**—Registration, Carnegie Institute of Technology, evening program consisting of two-semester credit courses in experimental design, probability and mathematical statistics, and quality control and industrial statistics, for further information regarding these courses or graduate and undergraduate day courses, write to Prof. Edwin G. Olds, Department of Mathematics, Carnegie Institute of Technology, Pittsburgh 13, Pa.

. . . **27**—Regional Technical Conference, "Hot Runner Molding," Hotel Niagara Falls, N. Y., sponsored by Society of Plastics Engineers, Inc., contact R. W. Miler, 3 Hillview Center, Lewiston, N. Y.

OCTOBER

. . . **7-11**—Supervisory Development Course 2, given in three one-week units (Oct. 14-18, Nov. 11-15), Penn Sherwood Hotel, Philadelphia, sponsored by AMA, contact Course Registrar, American Management Association, Inc., 1515 Broadway, New York 36, N. Y.

. . . **8**—Regional Technical Conference, "Isocyanites," Curtis Hotel, Minneapolis, Minn., sponsored by Society of Plastics Engineers, Inc., contact Paul Becker, Honeywell Regulator Co., 2733 4th Ave., South, Minneapolis, Minn.

. . . **16-18**—Eleventh Annual New England QC Conference, Stratfield Hotel, Bridgeport, Conn., sponsored by the New England sections of ASQC, program details and registration forms can be obtained by writing to Carl W. Nickerson, Registration Chairman, c/o Wentworth Institute, Boston 15, Mass.

. . . **17**—Regional Technical Conference, "Polyethylene," Hotel Carter, Cleveland, Ohio.

sponsored by Society of Plastics Engineers, Inc., contact W. A. Messina, 23817 Cliff Drive, Bay Village, Ohio.

. . . **18-19**—First Annual QC Technical Conference, Philadelphia, Pa., sponsored by the Chemical Division, ASQC.

. . . **24-25**—12th Midwest QC Conference, Chicago, Ill., sponsored by Midwest sections of ASQC, contact A. Jackson, Birtman Electric Co., 1800 N. Spaulding Ave., Chicago, Ill.

. . . **28-31**—2nd Winter Meeting, Henry Hudson Hotel, New York, N. Y., sponsored by American Nuclear Society, contact John Burt, J. M. Mathes, Inc., 260 Madison Ave., New York 16, N. Y.

NOVEMBER

. . . **6-8**—10th Annual Conference on Electronic Techniques in Medicine and Biology, Boston, Mass., sponsored by ISA and AIEE.

. . . **11**—Regional Technical Conference, "Plastics for Air-Borne Electronics," Ambassador, Los Angeles, Calif., sponsored by Society of Plastics Engineers, Inc., contact L. J. Costanza, 8017 Holy Cross Pl., Los Angeles 47, Calif.

JANUARY

. . . **13-17**—Supervisory Development Course 3, given in three one-week units (Jan. 20-24, Feb. 24-28), Penn Sherwood Hotel, Philadelphia, sponsored by AMA, contact Course Registrar, American Management Association, Inc., 1515 Broadway, New York 36, N. Y.

4th Annual Western QC Conference

The 4th Annual Western QC Conference—sponsored jointly by the Western Quality Control Conference Council and the Electronics Division, Aircraft Division, and San Francisco Bay Area section of ASQC—will be held at the Mark Hopkins Hotel in San Francisco on Sept. 9-10. For Bay Area quality control practitioners this will be an excellent opportunity to attend one of the leading conferences of the year. Out-of-town visitors will be able to combine conference attendance with vacation plans.

A varied program of outstanding speakers has been arranged covering both general and technical aspects of the quality control field. There will be special sessions on quality control practices in the food, aircraft, and electronics industries. A new feature of this year's conference will be a special luncheon for management personnel who have an interest in quality control but who may be unable to attend the whole conference. A program for the ladies is also planned.

The impressive list of speakers includes: James Wiborg, Leon Gilford, Frank O. Squires, Leon Bass, Harold Dodge, H. B. Epstein, Jack Mannion, R. B. Wittman, Frank Hunsicker, R. D. McKirahan, S. Hotchmer, J. L. Henderson, J. R. Adlord, K. R. Willhite, Wm. W. McIlhenny, R. J. Corlett, S. P. Cartwright, J. Y. McClure, Norman Garner, C. J. Smith, G. Judd, Pearson Monohar, J. H. Toulouse, Chester W. Lindsay, Robert Stevenson, David Hill, Wade R. Weaver, CDR J. A. Barker, P. Finkelstein, Robert S. Quinn, Harry Romig, Seymour Lorber, Silas Williams, Besse Day, Frank R. Del Priore, W. G. Ireson, Finley Carter, W. A. MacCrehan, W. H. Lassen, Louis B. Kahn, D. K. Schultz, C. R. Sheaffer, Paul E. Bruce, M. L. Lipow, D. C. Hartvigsen, D. K. Lloyd, Howard F. Heap, John E. Ogden, R. E. Webster, Ronald E. Hillblom, Robert McKennan, Waino W. Suojanen, Howard C. Todt, Ralph Kuehn, R. C. Haws. Further information may be obtained by writing to the conference, P.O. Box 2556, San Francisco 26, Calif.

New England QC Conference

The New England sections of ASQC are co-sponsors of the Eleventh new England QC Conference to be held Oct. 16-18 at the Stratfield Hotel, Bridgeport, Conn. The theme of the conference is "Quality control—the proving grounds for tomorrow's ideas."

A series of "management seminars" will be aimed at initiating the new manager conferee as well as enlightening those repeating in attendance. Seminar leaders are Leonard Seder, James H. Davidson, and Dorian Shainin. Messrs. Seder and Shainin are well known quality control consultants and Mr. Davidson is equally well known as manager of statistical methods for General Electric. As in past years, the number of participants will be limited and will be accepted by advance registration only.

For those in the research or engineering fields, three topics by three top speakers will be offered. Dr. Robert Lusser, reliability coordinator for Redstone Arsenal, will present "The notorious unreliability of complex equipment." Along the same vein will be the topic "Control of complex assemblies," which is the subject of A. E. Aubin's address. Mr. Aubin is chief quality control engineer for Royal McBee Corp. Ervin F. Taylor, Atomic Fuel Dept., Westinghouse Electric Co., will present a topic that is not new but is a statistical expression of pre-statistical quality control intuitive sampling—"Discovery Sampling."

Cost and accounting specialists will be within their "limits" when A. C. Rosander, Internal Revenue Dept., presents "Quality control in accounting," as well as when "Direct savings from quality records" is presented by E. W. Ellis, United Aircraft.

These plus other subjects and speakers make a diversified program that should prove both beneficial and interesting to personnel from all levels of manufacturing operations.

Registration blanks and a program copy may be obtained by writing to Carl W. Nickerson, c/o Wentworth Institute, Boston 15, Mass.

Bibliography

JOSEPH MOVSHIN, *Editor*

Assisted by the Editorial Committee, St. Louis Section, ASQC

9220 Old Bonhomme Road, St. Louis 24, Mo.

APPLICATION—
METAL WORKING

10TH ANNUAL ISSUE FEATURING QUALITY CONTROL
(Tooling and Production, v. XXIII, n. 2, May, 1957)

This is the Annual Quality Control Feature Issue of Tooling and Production. It includes various articles dealing with Quality Control subjects, including the following:

TOOL PROOFING: A MEANS OF QUALITY CONTROL, by A. S. Billings, Director, Quality Control, Ryan Aeronautical Co. (San Diego, California) p. 18.

The importance of tool control and tool design as a means of controlling quality is stressed in this "Talk of the Month." Organizational requirements for good Quality Control are also indicated.

PEG-BOARD QUALITY CONTROL, by Ralph B. Nottingham, Mgr. Quality Control Dept., Brush Electronics Co. (Cleveland, Ohio) p. 78.

Where process capability is well within the tolerance, but resetting may be required due to tool wear, it is possible to use a simple board arrangement whereby process shifts can be detected to certain predetermined probability limits. As pieces are checked, they fill spaces in the peg board according to their dimensions. When a number of high or low pieces exceeds the predetermined number allowed, a change is indicated.

PROVIDING IN-PROCESS QUALITY CONTROL FOR TRANSFER LINES, by George Whitehouse, Vice Pres., Snyder Tool & Engineering Co. (Detroit, Michigan) p. 81.

The importance of in-process gaging and examples of in-process gaging used are the subjects of this article. The need for designing in-process gaging in automatic equipment is stressed.

100 PERCENT INSPECTION OF 12,000 SMALL MOTORS DAILY, by Raymond J. Kramer, Quality Control Mgr., The Leece-Neville Co. (Cleveland, Ohio) p. 87.

Details of the performance and noise inspection of small motors are given.

AUTOMATED CONTROL OF GEAR QUALITY, by Ben F. Bregi, Vice Pres., National Broach & Machine Co. (Detroit, Michigan) p. 91.

Quality Control system and equipment for gaging gears produced on an automation line is given.

TRAINING FOR EFFECTIVE QUALITY CONTROL, by W. J. Masser, Mgr. Quality Control Eng. Service, Gen. Electric Co. (Schenectady, New York) p. 97.

In this paper, the author outlines the role of Quality Control as an overall means of producing a desired product at the right cost. Quality Control is described as a measurement tool affecting all phases of the organization and providing a measure of accomplishment.

ENGINEERING & EXPERIMENTS

SELECTION OF MOST EFFICIENT EXPERIMENTAL DESIGNS, by Charles A. Bicking, Mgr. Quality Control Branch, Research & Development Div., The Carborundum Co., Niagara Falls, New York.
(Tooling & Production, v. XXIII, n. 1, Apr., 1957, p. 119-125)

"Most efficient" is defined in a statistical sense as the design in which the error variance is minimized. From this, the author describes the nature of good designs and presents examples of poor designs in an experiment. Designs involving many factors are also considered as is the grouping of data.

MANAGEMENT & PERSONNEL, GENERAL

THE NEW APPROACH TO QUALITY CONTROL, by A. V. Feigenbaum, Mgr. of Quality Control, General Electric Company.
(Factory, v. 115, n. 3, Mar., 1957, p. 116-123)

This article, in question and answer form, reviews the modern trend in Quality Control to a broader concept of "Total Quality Control." The need for better trained personnel and the broader organizational implications of this approach are discussed. The economic aspects of Quality Control in producing better quality at lower total cost are considered.

10-POINT PLAN FOR PROGRESS, by Kenneth F. Leaman, American Bosch Arma Corp., Springfield, Mass.)
(Factory, v. 115, n. 4, Apr., 1957, p. 84-87)

In outlining this 10-point plan for progress, Quality Control is one of the areas of consideration. A brief paragraph describes the progress made in this area.

INDUSTRIAL MANAGEMENT

MANAGEMENT POSSIBILITIES WITH QUALITY CONTROL METHODS, by Charles A. Bicking, Mgr. Quality Control Branch, Research and Development Division, The Carborundum Co., Niagara Falls, New York
(Forest Products Jrl., v. VII, n. 1, Jan., 1957, p. 16-19)

Quality Control may be applied to a great many Industrial Management problems and areas. Some eighteen of these are listed. Included are problems in the fields of Personnel, Accounting, Sales, and Inventory Control and Management. Examples of this type of application of Statistical Quality Control techniques are given in a control chart for inventory control and a percentage control of accidents. Bibliographies of some 47 references are included.

SOME STATISTICAL CONSIDERATIONS IN WORK SAMPLING, by Richard W. Conway, Dept. of Industrial & Engineering Administration, Cornell University
(Journal of Industrial Engineering, v. VIII, n. 2, March-April, 1957, p. 107-111)

Some of the statistical basis and mathematical probability of work sampling are discussed and described. Probability using the binomial model is developed from the mathematical expressions involved. Models for stratified sampling and for "non-independence" are also given.

MISCELLANEOUS

SHADOWGRAPHS—FOR FASTER, SURER INSPECTION, by John C. Roche (Military Products Chief Draftsman) and Leonard S. Greer (Design Engineer) Burndy Corporation, Norwalk, Conn.
(Factory, v. 115, n. 4, Apr., 1957, p. 106-109)

The use of comparators in the inspection of various parts is described. The article is illustrated with specific parts and the methods used for visual inspection for certain details.

QUALITY—LOUD AND CLEAR
(Factory, v. 115, n. 4, Apr., 1957, p. 134)

A brief article describing a PA system whereby inspectors on an automotive assembly line inform assemblers back on the line of defects as they occur.

INSURING MEASUREMENT RELIABILITY, by A. L. Izzarone, Dept. Chief, Machine & Test Set Maintenance Dept. (Western Electric Company, Allentown, Pa.)
(Production, v. 39, n. 6, June, 1957, p. 95-99)

This article describes the work of a "Meters and Standards Section" at Western Electric Company, Allentown, Pennsylvania Works. The importance of assuring that test instruments are reliable before judgment of the product can be made is indicated. X and R charts are used both for product and instrument control purposes.

QUALITY CONTROL—AUTOMATIC AND ADAPTABLE
(Production, v. 39, n. 4, Apr., 1957, p. 76-79)

High speed automatic manufacturing equipment requires inspection facilities that can keep pace with production. The A-C Spark Plug Division in Flint, Michigan, has developed automatic inspection equipment which can sample check 2,500 pieces per hour. The six station rotary hopper feed mechanism checks various dimensions at each of the six stations. These include such dimensions as: the OD of a round portion, ID's of several shoulders and groove width on a go, no-go basis. Other automatic high speed gaging units are also illustrated.

MODERN AIR GAGES HOLD THE LINE ON GAGING COSTS, by E. M. Procopio, Plant Superintendent, Accurate Bushing Co., Garwood, New Jersey.
(Tooling & Production, v. XXIII, n. 1, Apr., 1957, p. 81-84)

This article describes the Federal Dimensionair gaging system used for the measurement of drilled bushing inside diameters.

SAMPLING PLANS & RELATED TOPICS

LOW COST "MULTIPLE SAMPLING," by Richard M. Jacobs, Reliability Engineer, Defense Electronic Products Div., Radio Corp. of America
(Production, v. 39, n. 5, May, 1957, p. 86-90)

Selected references in the Bibliography of *Industrial Quality Control* are obtained from the following sources:

The International Statistical Institute, *International Journal of Abstracts on Statistical Methods in Industry.*

This article outlines the application of multiple sampling as established by RCA for certain products. Basically, AQL's are standardized for a great many products. Defect classification based on AQL assignments are used. Multiple sampling plans are presented on a chart together with product codes. Operating characteristics for various plans are shown.

TRAINING & EDUCATIONAL

PROPOSED PROGRAM FOR GRADUATE STUDY IN OPERATIONS RESEARCH AND SYSTEMS ENGINEERING, by M. E. Salveson, Consultant, Operations Research & Synthesis Consulting Services, General Electric Company.
(Journal of Industrial Engineering, v. VIII, n. 2, March-April, 1957, p. 101-106)

The enthusiasm and interest in "Operations Research" and "Systems Engineering" requires the development of more trained personnel in these fields. As background information, the history of "Operations Research" is briefly illustrated with examples from World War II. The overall attitude and concept of the "Operations Research" approach is described, along with the scope in application and education. An outline of a suggested curricula is given showing both general engineering subjects and the specific subjects of "Operations Research."

POSITIONS AVAILABLE

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- analyzing failure data;
- establishing quality control standards;
- establishing environmental criteria;
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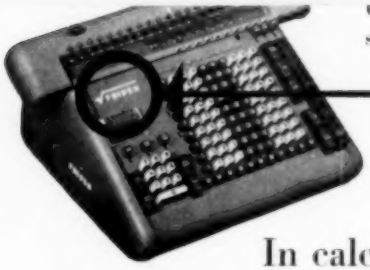

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